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SUGARBEET RESEARCH

1994 REPORT

FOREWARD

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Trade names occur in this report solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture or the Beet Sugar Development Foundation.

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SUGARBEET RESEARCH

1994 Report

Section A

U.S. Agricultural Research Station, Salinas, California

Dr. J.E. Duffus, Plant Pathologist
Dr. R.T. Lewellen, Geneticist
Dr. H.Y. Liu, Plant Pathologist
Dr. G.C. Wisler, Plant Pathologist
Dr. M.H. Yu, Geneticist

Cooperation:

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DUFFUS, J.E. Diseases Vectored by whiteflies: Etiology, ecology, geographical distribution and possible control measures. Proc. Fifth Arab Congr. Plant Protection, Fez, Morrocco. B. Ezzahiri and M. Bohache, Eds., p. 13. 1994.

The whitefly-transmitted viruses produce a wide and divergent group of diseases, most of which have not been characterized. The agents are transmitted by at least three whitefly species in the nonpersistent, semipersistent, persistent and by biological mechanisms. The viruses cause significant losses throughout the world and are responsible for some 70 important diseases in the tropical and sub-tropical areas. Recent years have shown an increase in losses in wide areas north and south of the tropics, approaching areas of intensive agricultural production. The whitefly-transmitted diseases have been characterized in general on the basis of their transmission by whiteflies and the activity of the agents on host plants, such as symptoms and host range. A compilation of available data on the viruses themselves would suggest at least seven groups of viruses differing in type of virus particle, symptom type, and vector relationships. The two major groups of whitefly-transmitted viruses of worldwide importance (the geminiviruses and closteroviruses) are differently transmitted by biotypes of *Bemisia*. This vector specificity impacts virus distribution and epidemiology. Transmission systems may be valuable to trace origins of viruses and their vectors.

DUFFUS, J.E. Whitefly-borne viruses. Internat. Bemisia Workshop. Bemisia 8:15. 1994.

The whitefly-transmitted viruses induce a wide and divergent group of diseases, most of which have not been characterized. The agents are transmitted by at least three whitefly species in the nonpersistent, semipersistent, persistent, and by biological mechanisms. The viruses cause significant losses throughout the world and are responsible for some 70 important diseases in the tropical and subtropical areas. Recent years have shown an increase in losses in wide areas north and south of the tropics, approaching areas of intensive agricultural production such as the southern United States and the Mediterranean region.

The whitefly-transmitted diseases have been characterized in general on the basis of their transmission by whiteflies and the activity of the agents on host plants, such as symptoms and host range. A compilation of available data on the viruses themselves would suggest at least seven groups of viruses differing in type of virus particle, symptom type, and vector relationships. These include geminiviruses, and viruses similar to the closteroviruses, caraviruses, potyviruses, nepoviruses, luteoviruses and a DNA-containing rod-shaped virus.

Recent changes in importance and world distribution of Bemisia seem to be related to movement and displacement of biotypes or species. These movements of insects with different host and vector affinities have significantly altered epidemiological characteristics of some whitefly transmitted viruses.

The demonstration of vector specificity between biotypes implies that similar vector specificity may occur in other areas of the world and that virus distribution may be dependent on the geographical distribution of the whitefly biotypes. Transmission systems may be a convenient tool to trace the origins of viruses and their vectors.

DUFFUS, J.E. Whitefly-transmitted yellowing viruses of the Cucurbitaceae. Proc. Cucurbitaceae 94, South Padre Island, TX. p. 1. 1994.

Whitefly-transmitted yellowing viruses of cucurbits are causing severe economic losses throughout the world. Three distinct whitefly transmitted cucurbit viruses have been distinguished-- beet pseudo yellows (BPYV), lettuce infectious yellows (LIYV), and cucurbit yellow stunting disorder virus (CYSDV).

BPYV virus has caused severe losses in greenhouse grown cucurbit crops throughout North America, Europe, and Asia. It has been reported from France, The Netherlands, Japan, Italy, Spain, England, Australia, and Bulgaria. Since 1982, the incidence in melon crops under protected environments and outdoors on the Mediterranean coast of Spain has continually increased inducing considerable economic losses. The virus has a wide host range of important crop, weed and ornamental hosts. BPYV is transmitted by *Trialeurodes vaporariorum* in a semi-persistent manner and is retained by the insect for 6 days. Purified preparations contained long, flexuous particles 1500 nm long. The virus has been termed cucumber yellows, muskmelon yellows, melon yellows, and cucumber chlorotic spot virus, but these isolates have not been shown to be distinct from BPYV.

A distinct whitefly transmitted virus, LIYV, was reported from the desert regions of California and Arizona in 1981. The virus, transmitted specifically by the A biotype of *Bemisia tabaci*, has a wide host range of important crop hosts. LIYV has long filamentous particles 1800 nm long which are retained by *Bemisia* for 3 days. The virus has been also found in Texas and Mexico.

In the early 1980's a yellowing and stunting disorder of cucurbits was noticed in the Middle East. The disease has been found in Jordan, Israel, UAE and Turkey. The virus, CYSDV, has a narrow host range, mainly in the Cucurbitaceae. CYSDV is transmitted specifically by the B biotype of *B. tabaci* and is retained by the vector for 10 days. Purified preparations contained long, flexuous particles 1200 nm long.

DUFFUS, J.E. and H.Y. LIU. The effects of whitefly population changes on lettuce infectious yellows virus epidemiology. Sweetpotato Whitefly: 1994 Supplement to the Five-Year Plan. U.S. Dept. Agr. ARS no. 112:48. 1994.

Lettuce infections yellows virus (LIYV) has been a limiting factor in the production of crops in the desert regions of southwestern USA since 1981. The virus, which is vectored by the sweetpotato whitefly, attacks at least 10 major agricultural crops including lettuce, cantaloupe, cucumber, melons, squash, watermelons, sugarbeet, and carrots. The economic impact of LIYV infections in crops grown in the southwest desert regions was devastating. Lettuce, sugarbeet and melon plantings during the 1980's were virtually 100% infected. Yield losses in lettuce were in the range of 50-70%. Losses of sugarbeets have been estimated at 20-30%, or approximately $9 million per year. The losses in cucurbits were in the range of 20-50%. In addition to these losses, the limited availability of produce, especially lettuce, during the late fall and winter periods boosted consumer prices in some instances over 600%, causing great losses to consumers.

Following the introduction of biotype "B" into the southwest desert whitefly population in 1990 and the establishment of its gene pool into the resident population, a number of important changes in LIYV epidemiology took place. The new biotype and hybrid populations developed much higher population levels than the "A" biotype. The new populations were much poorer vectors of LIYV (almost 100 fold less efficient). The new population developed more rapidly and were so destructive to melons that virtually no fall melons were planted in 1992. Thus, in spite of record whitefly populations, the absence of the major source of the LIYV (fall melons) resulted in very low incidence of virus in 1991 and 1992 fall crops (less than 0.1%). The virus was still present in the region but was not of economic significance, and record lettuce and sugarbeet yields have resulted.

DUFFUS, J.E., H.Y. LIU, and G.C. WISLER. Distribution of tomato infectious chlorosis virus in California. Sweetpotato Whitefly: 1995 Supplement to the Five Year Plan. U.S. Dept. Agr. ARS (in press). 1995.

A virus disease of tomato, first described in 1994 from southern California (1), has now been found in northern California. Tomato infectious chlorosis virus (TICV), first found in the Orange County area of southern California in 1993, induced interveinal yellowing, necrosis and severe field losses in the Irvine hills and valley region. The virus was transmitted by *Trialeurodes vaporariorum* (Westwood) but not by either the A or B biotypes of *Bemisia tabaci*.

Leaf dips and purified preparations showed flexuous filamentous particles similar to closteroviruses. Field and laboratory

observations have established that the virus also occurs in commercial greenhouses and field plantings in San Diego County and is established in wild hosts in the southern California region. The virus has recently been found in high incidence in research greenhouses in the Davis area of California. These occurrences have been confirmed by transmission and serological tests.

(1) Duffus, James E., Liu, H.Y. and Wisler, G.C. A new closterovirus of tomato in southern California transmitted by the greenhouse whitefly (*Trialeurodes vaporariorum*). Phytopathology 84:1072-1073. 1994.

FRANC, G.D., C.M-S. BEAUPRE, E.D. KERR, and J.E. DUFFUS. <u>Movement of the rhizomania vector and associated viruses in surface water and wind-blown soil</u>. Jour. Sugar Beet Res. (in press). 1995.

Surveys were done in eastern Wyoming and western Nebraska to determine the potential for movement of *Polymyxa betae*, the vector of the rhizomania virus and other sugarbeet viruses, in flowing surface water and wind-blown soil. Monthly water collections were made from the North Platte River during a 1 year survey period. Five sites, representing locations on the river upstream from agricultural areas to downstream sites, were repeatedly sampled. Particulates in water samples were concentrated by filtration through celite which, in turn, was tested in a greenhouse bioassay for *P.betae*. Results showed that *P.betae* could be detected throughout the survey period. However, the two upstream sites had detectable levels of *P.betae* present only 33% of the time while the three downstream sites had detectable levels present ca. 75% of the time. Aerosol samples, which included wind-blown particulates, were collected on cellulose air filters with the aid of high volume aerosol samplers. Samples were collected over a 12 month period at two sample sites. After exposure, filters were aseptically cut into ca. 2.5 cm squares, which were then used to amend previously steamed sand. The resulting sand-filter mixture was tested via a greenhouse bioassay. Results showed that 42% (38/90) and 59% (20/34) of the filter samples had detectable levels of *P.betae* present for western Nebraska and eastern Wyoming collection sites, respectively. Results showed that resting spores of *P.betae* were readily detected in both flowing surface water and wind-blown particulates.

HARRIS, J.F., Z. PESIC-VAN ESBROECK, and J.E. DUFFUS. <u>Anatomy of a virus vector</u>. Intercept. Ltd. Publishers, U.K. (in press). 1995.

In this chapter on the anatomy of *Bemisia*, we have attempted wherever possible to give equal weight to form and function. Also, wherever possible, form and function in *Bemisia* have been

compared with form and function in similar structures and organ systems in other, more thoroughly studied and better understood homopteran vectors of plant viruses. Finally, knowledge and ideas resulting from this comparative approach to understanding *Bemisia*'s anatomy served as a basis for our relating *Bemisia*'s morphology to the processes of noncirculative and circulative plant virus transmission.

HARRIS, K., Z. PESIC-VAN ESBROECK, and J.E. DUFFUS. <u>A morphological study of *Bemisia* organ systems of known importance in homopteran virus transmission</u>. Internat. Bemisia Workshop. Bemisia 8:15-16. 1994.

To what extent does whitefly virus transmission mimic that by aphids? Does ingestion-egestion behavior contribute to noncirculative transmission by whiteflies? Are *Bemesia* noncirculative viruses "cuticula-borne": carried externally on the stylet or internally on cuticula lining the feeding apparatus or fore alimentary canal? Does helper component bind virus to cuticula? Do geminiviruses traverse *Bemisia* as circulative viruses do aphids? Do *Bemisia*'s accessory salivary glands influence virus transmissibility and vector specificity and efficiency?

To begin answering such questions, we researched the morphologies of *Bemisia*'s salivary and alimentary systems. The former consists of paired primary and accessory glands in the prothorax, to either side of the thoracico-abdominal ganglion. Ducts from each pair fuse to form lateral ducts that travel anteroventrally to the midline, continue in parallel through the hypopharynx, and fuse to form a single afferent duct before emptying into the salivary pump. Saliva exiting the pump, *via* an efferent duct, enters the salivary canal of the maxillae where food from the maxillary food canal enters the precibarium. Food passes from the precibarium to the cibarial pump and per os, to the foregut (pharynx and esophagus). The long, narrow, thin-walled esophagus extends from the tentorium to the base of the abdomen where it enlarges and, along with the anterior midgut, mingles with the anterior hindgut to form a filter changer. The midgut then proceeds dorsocaudally (descending midgut) before looping antero-ventrally (ascending midgut) back toward the filter chamber area, broadening the giving off two fingerlike malpighian tubules at its juncture with the hindgut. Upon leaving the filter chamber, the anterior hindgut is a fist broad (ileum) and then narrow (colon), before broadening (rectal sac) and constricting once again (rectum) in its dorsocaudal course to the vasiform orifice.

The anatomical information, combined with immunocytochemistry and both light and electron microscopy, has enable us to study the fate of viruses in *Bemisia*. (*L*)

LEWELLEN, R.T.   Breeding for dual resistance in sugarbeet to cyst
nematode and rhizomania.   J.Sugarbeet Research 31: (in press).
1995.

The homozygous, sugarbeet cyst nematode (SBCN) (*Heterodera
schachtii*) resistant line B883 from the Netherlands was used as
the source of nematode resistance (NR).   B883 had been developed
from Savitsky's 19 chromosome alien addition line with NR from
Beta procumbens.   B883 and C603 and C604 developed at Salinas
from B883 are true breeding for NR, but they do not possess other
requirements for disease resistance and productivity; they are
very low in sucrose content.   In addition, hybridization
reinstates heterozygosity for NR that creates lower than normal
transmission rates making recovery of new, useful, true-breeding
NR lines difficult.   NR genotypes have retarded flowering and
pollen development and a tight linkage with crown galling and
shoot proliferation.   This linkage to galling is very useful to
identify NR plants in segregating populations.   Ultimately,
galling is potentially deleterious, but field tests under high
plant populations suggest that it will be mostly benign.
Resistance to rhizomania using the Holly gene was incorporated
into the NR breeding program.   All recent scoring, selection, and
performance testing was done under field conditions with
infestations to both rhizomania and SBCN.   Segregating lines
through backcross four have been developed with dual resistance.
Each succeeding backcross has given expected root yields and
improved sucrose content; within the backcross populations, the
nematode susceptible segregates approach the level of the
recurrent parent as expected but the NR counterparts remain 1-3%
points lower in sucrose content.   Reciprocal backcrosses had
different rates of NR transmission.   Among different backcross
lines, transmission rates through the male ranged from 1-16% and
3-26% through the female rather than the theoretical 50% rate.   A
modified backcross procedure using homozygous NR pollinators in
parallel to conventional backcrossing should greatly increase the
rate of recovering new homozygous NR lines and synthetics useful
for parental line development and population improvement.

LEWELLEN, R.T.   Performance of near-isolines of sugarbeet with
resistance to rhizomania from different sources.   58th IIRB
Congress, Beaune, France.   20 June 1995 Abstr. (in press).   1995.

Rhizomania, caused by beet necrotic yellow vein virus (BNYVV), is
one of the most important diseases of sugarbeet worldwide.
Screening germplasm resources of *Beta* spp. for resistance has
been a program objective at Salinas since 1984.   In most
instances, field tests were used under moderate to severe
rhizomania conditions.   Serological tests were employed only to
assure that BNYVV was present and to help confirm visual
evaluations.   Identification and selection of resistance was
based upon visual symptoms.   Eleven known or newly identified
sources of resistance were backcrossed individually into
rhizomania susceptible breeding line C37 to generate near-

isolines. Sources of resistance transferred were from sugarbeet, Swiss chard, annual weed beet, and collections of *B. vulgaris* subsp. *maritima* from the Mediterranean and northwest Europe. In general, it was observed that with each backcross to C37, line vigor, and to some degree, resistance to rhizomania were decreased. All isolines were significantly higher yielding than C37 when tested under rhizomania conditions. Significant differences also occurred among the resistant isolines. At this time, other than *Rz* (Holly) gene, the inheritance patterns and relationships have not been determined for these sources of resistance. Most appear to be conditioned by major dominant alleles. There is empirical evidence that these genes do not condition immunity and may be modified by other genetic and environmental variability. In most isolines, resistance is probably to BNYVV, but resistance to *Polymyxa betae* has not been excluded. In addition to the sources of resistance backcrossed into C37, other *B. vulgaris* subsp. *maritima* accessions have been identified with resistant individuals.

LEWELLEN, R.T. <u>Registration of C762-17, a Parental Line of Sugarbeet</u>. Crop. Sci. 34:319. 1994.

Sugarbeet (*Beta vulgaris* L.) parental line C762-17 (Reg. no. PL-33, PI 560130) was developed by the USDA-ARS. This line was released in 1989 for potential use as a parent in hybrids. A cytoplasmic male-sterile (CMS) equivalent has been developed and is available. C762-17 is a monogerm (*mm*), O-type, green hypocotyl (*rr*), self-fertile (S^f) line that will segregate at a low frequency for genetic male sterility (*A:aa*). It has high resistance to curly top virus and high combining ability (hybrid performance) for root and sugar yield. It has low sucrose concentration traits. As a line, it has a small, compact, dark green canopy. As a line and in hybrids, C762-17 has demonstrated moderate resistance to bolting and powdery mildew, caused by *Erysiphe polygoni* DC. It shows fair resistance or tolerance to virus yellows (beet yellows and beet western yellows virus complex) and lettuce infectious yellows virus. It is susceptible to Erwinia root rot caused by *Erwinia carotovora* (Jones) Bergey et al. subsp. *betavasculorum* Thomson et al.

C762-17 was selected from the cross [S_1(population-755aa x C546)]aa x C718 on the basis of early testing for curly top resistance and hybrid performance for sugar yield. A version of popn-755 was released as C310 (2). C546 (3) and C718 (1) were widely used as parental lines. C762-17 traces to one specific cross (cross 17) between two plants. Line C762-17 was increased from the original cross without further within-line selection and should exhibit some degree of genetic variability. From the original set of greenhouse crosses among plants of [S_1(popn-755aa x C546)]aa x C718, four to six individual S_0 plants within each F_1 line were crossed to a common CMS line. Each of these F_1 CMS hybrids was then topcrossed by a common multigerm tester to

produce experimental 3-way hybrids. Either a nested design of
hybrids within and across S_1 lines or a composite of hybrids
within an F_1 line was used to test hybrid performance for gross
sugar yield in trials at Salinas and Brawley, CA. Based upon the
best mean 3-way hybrid performance among the F_1 lines, the O-type
(CMS rating) of the F_1 CMS hybrids, and curly top reaction of the
F_1 lines from greenhouse tests, three F_1 lines were selected for
further evaluation. With the aid of genetic male-sterile
segregates within the S_1 increases of these three lines, topcross
hybrids were made. These single-cross hybrids were evaluated at
Salinas under nondiseased and diseased (virus yellows and powdery
mildew) conditions and at Brawley, CA under lettuce infectious
yellows conditions. Based upon these trials, the line that was
released as C762-17 was selected, increased, backcrossed to
produce a CMS near-equivalent, and retested in variety and
disease nursery trials. The performance of this line in
experimental hybrids and disease nurseries suggested that hybrid
performance and reaction to disease can be identified very early.

LEWELLEN, R.T. <u>Registration of C790-6, C790-15, and C790-54</u>
<u>Parental Lines of Sugarbeet</u>. Crop Sci. 34:319-320. 1994.

Sugarbeet (*Beta vulgaris* L.) parental lines C790-6, C790-15, and
C790-54 (Reg. no. PL-34, PL-35, and PL-36; PI 564757, PI 564758,
and PI 564759) were developed by USDA-ARS in cooperation with the
Beet Sugar Development Foundation and the California Beet Growers
Association. These lines and their cytoplasmic male-sterile
(CMS) near-equivalents were released in 1992 for potential use as
parents in hybrids. These lines are known to combine well with
multigerm testers and have adaptation throughout California.

C790-6, C790-15, and C790-54 are monogerm (*mm*), O-type, self-
fertile (S^f), and segregate for genetic male sterility (*aa*).
C790-54 is homozygous for red hypocotyl (*RR*) color. C790-6 and
C790-15 segregate for hypocotyl color. All have fair to moderate
resistance to bolting, curly top virus, and the virus yellows
complex (beet yellows and beet western yellows viruses). C790-15
has high resistance and C790-6 and C790-54 have moderate
resistance to powdery mildew caused by *Erysiphe polygoni* DC. All
have moderate susceptibility to Erwinia root rot caused by
Erwinia carotovora (Jones) Bergey et al. subsp. *betavasculorum*
Thomson et al. As components of single-cross experimental
hybrids, they expressed high combining ability for sugar yield in
trials at Salinas, Brawley, and Davis, CA under both nondiseased
and diseased conditions. All have moderately good sucrose
concentration. C790-15 appeared to be superior for sugar yield
combining ability; in most trials in 1992 and 1993, its hybrid
ranked number one among all entries (commercial and experimental
hybrids) for sugar yield and powdery mildew resistance.

C790-6, C790-15, and C790-54 are sister lines that were selected
from population-790(C4). Population-790(C4) was released earlier
(2) and was developed by S_1 progeny recurrent selection for sugar
yield under prevailing disease conditions. Eight lines have been

released from earlier cycles of recurrent selection (1). The present releases appear to have better performance than these earlier releases or the cycle four or five synthetics in equivalent hybrids. For the fifth cycle of S_1 progeny recurrent selection, good monogerm, fully fertile plants were selfed in the field without pollen protection. The S_1 progeny were evaluated per se at Brawley under severe lettuce infectious yellows conditions and at Salinas in tests under virus yellows and moderate bolting induction conditions. Powdery mildew was epidemic at Salinas. The superior S_1 lines based upon per se performance for sucrose concentration, sugar yield, nonbolting tendency, and powdery mildew resistance were selected and, facilitated by genetic male-sterility, topcrossed to a multigerm tester. These experimental hybrids were evaluated under a wide range of conditions and diseases at Salinas and Brawley. From the performance of these S_1-TX hybrids, S_1 lines that ultimately became C790-6, C790-15, and C790-54 were selected, increased, and released. These lines should retain most of the genetic variation present in their original S_o plant because within-line selection was not practiced.

LEWELLEN, R.T. <u>Registration of C859 Germplasm of Sugarbeet Resistant to Rhizomania</u>. Crop Sci. 35:289-290. 1995.

C859 IS A SUGARBEET (*Beta vulgaris* L.) germplasm line (Reg. no. GP-147, PI 565285) developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation and the California Beet Growers Association and released in 1992. It segregates for major gene (*Rz*) resistance (5) to rhizomania caused by beet necrotic yellow vein virus. C859 is self-fertile (S^f) and segregates for monogermity, O-type, genetic male sterility, and hypocotyl color. In the sugarbeet breeding program at Salinas, these types of breeding lines have been called self-fertile, genetic male-sterile facilitated, random-mated populations (4). They are useful for population improvement and parental line extraction. C859 should be increased by harvesting seed from randomly mated, male-sterile plants. This insures that in the new synthetic each individual plant is either male sterile (a_1a_1) or heterozygous pollen fertile (A_1a_1). At the time of its release, a cytoplasmic male-sterile version (C859CMS) also was made available.

Monogerm, self-fertile, genetic male-sterile plants from population 1566 were used as the recurrent parent to produce C859. About 75% of population 1566 is composed of germplasm from curly top virus resistant C562 (2) and C563 (3) type sources and 25% from Fusarium stalk blight (*F. oxysporum* Schlecht. f. sp. *betae* (Steward) Snyd. & Hans.) resistant C566 (1). About 8% of C859 is from a multigerm line, the source of the *Rz* factor. After three backcrosses and reselections for resistance to rhizomania, the population was increased by harvesting seed from the monogerm, genetic male-sterile segregates. In addition to segregating for resistance to rhizomania, C859 will have genetic variability for high resistance to curly top virus and bolting.

The population will be moderately susceptible to virus yellows caused by beet yellows and beet western yellows viruses, powdery mildew caused by *Erysiphe polygoni* DC, and Erwinia root rot caused by *E. carotovora* (Jones) Bergey et al. ssp. *betavasculorum* Thomsen et al. Based upon the performance of the population and experimental population hybrids, in the absence of rhizomania, C859 has good general combining ability for sugar yield and low to intermediate sucrose concentration. C859 was evaluated as populations-1859, 2859, and 3859.

C859 should be useful as a source for developing potential monogerm, O-type parental lines that combine resistance to rhizomania, curly top, and bolting. It also should be useful as a source for continued population improvement and for combined disease resistance.

LIU, H.Y., G.C. WISLER, and J.E. DUFFUS. <u>Occurrence of vascular necrosis of sugarbeet in the Imperial Valley of California</u>. Jour. Sugar Beet Res (in press). 1995.

Since about 1981, a vascular necrosis syndrome (VNS) of sugarbeet has been observed in the Imperial Valley of California. Two soil-borne viruses have been isolated and identified. One of these viruses is isometric and approximately 26 nm in diameter. The particle morphology, protein coat subunits, and nucleic acid size are similar to those of tobacco necrosis virus (TNV). The serological relationship to TNV has also been demonstrated in agar double diffusion tests. Another spherical virus isolated from necrotic sugarbeet roots was serologically related to tomato bushy stunt virus. Random sampling of 50 beet fields conducted during 1994 indicated that 80% of the fields tested had VNS. Biological assays indicated that virus was recovered from 68% of the fields tested. The isolated viruses were TNV(6%), TMV(24%), TBSV(36%), and 34% were not identified. The etiology, economic impact, and the relationship of these viruses to the increasing vascular necrosis syndrome in the Imperial Valley is not known.

WISLER, G.C., J.E. DUFFUS, H.Y. LIU, E. KERR, and J.J. GALLIAN. <u>Incidence of two soil borne viruses of sugar beet in the U.S.</u> Phytopathology 84:1171. 1994

Soil tests for beet necrotic yellow vein virus (BNYVV) and beet soil borne mosaic virus (BSBMV) in sugar beet growing areas of the USA were summarized for 1992-1994. Only one field of 242 sampled in Nebraska had a 22% incidence of BNYVV, whereas BSBMV was found in 20% of fields tested. A region representing a 5.6 km radium in southeastern Idaho had a 7.6% incidence of BNYVV. Samples from Colorado had a 16.5% and 51% incidence of BNYVV and BSBMV, respectively. In samples from Wyoming and Michigan, BNYVV was not detected, but BSBMV was present in both states (9.1 and 6.6%, respectively). BNYVV was detected in 20% of samples from California, but to date no BSBMV has been detected.

WISLER, G.C., J.E. DUFFUS, H.Y. LIU, E.D. KERR, and J.J. GALLIAN. Occurrence of beet necrotic yellow vein virus and beet soil borne mosaic virus in the USA. Jour. Sugar Beet Res. (in press). 1995.

Soil tests conducted in cooperation with the USDA-ARS in Salinas, CA for beet necrotic yellow vein virus (BNYVV) and a partially characterized virus termed beet soil borne mosaic virus (BSBMV) in the sugar beet growing areas of the USA were summarized for 1992-1995. BNYVV was found in two counties in Nebraska, with 5.7% incidence, whereas 29% of samples were found to be infested with BSBMV. In 1994, BNYVV incidence in Idaho was restricted to a 5.6 km radius of southeastern Idaho, but by 1995, BNYVV had been confirmed in several beet growing areas along the Snake River, extending into eastern Oregon (personal comm., J.J. Gallian and D. Traveler). Samples from Colorado had a 6.4% and 39% incidence of BNYVV and BSBMV, respectively. BNYVV was not detected in samples from Wyoming or Michigan, but BSBMV was present in both states (9.1 and 6.1%, respectively). BNYVV was not detected in samples from Ohio or Montana. BNYVV was detected in 13.8% of samples from California, but to date, no BSBMV has been detected or isolated by tests performed at the USDA.

WISLER, G.C., H.Y. LIU and J.E. DUFFUS. Beet necrotic yellow vein virus and its relationship to eight sugar beet furo-like viruses from the United States. Plant Disease 78:995-1001. 1994.

The degree of relatedness among five beet necrotic yellow vein virus (BNYVV) isolates and other rigid, rod-shaped viruses (beet soil-borne mosaic virus; BSBMV) isolated from sugar beet roots from the U.S.A. was evaluated serologically and through polymerase chain reaction (PCR) and host range studies. Polyclonal antisera to the C-terminal 60 amino acids of the BNYVV coat protein (CP), the 14- and 75-kDa nonstructural proteins, and seven monoclonal antibodies were specific to BNYVV in western blots. Antisera to the BNYVV coat protein and its cloned CP reacted strongly with all five BNYVV isolates (22-kDa), but weakly with the BSBMV isolates of sugar beet (24-kDa). Antisera to the 42-kDa nonstructural protein reacted with all BNYVV isolates (42-kDa) and with all but one BSBMV isolate (44-kDa). No cross-reactivity was observed in reciprocal immunodiffusion tests between BNYVV and the BSBMV isolates. No products were observed for the BSBMV isolates analyzed in PCR using 10 BNYVV primer pairs. The eight BSBMV isolates investigated induced symptoms different from those of BNYVV in several hosts. Two BSBMV isolates tested were transmitted by *Polymyxa betae*. These eight BSBMV isolates are presumed to be furoviruses distinct from BNYVV.

WISLER, G.C., H.Y. LIU, and J.E. DUFFUS. Genomic comparisons among several furo-like viruses of sugar beet. Jour. Sugar Beet Res. (in press). 1995.

The degree of relationship among five beet necrotic yellow vein virus (BNYVV) isolates and eight other furo-like viruses termed

beet soil borne mosaic virus (BSBMV) from sugar beet in the United States was evaluated by serology of both structural and nonstructural proteins, particle morphology, host range, fungal transmission, and analysis of the RNA genomes. Polyclonal antisera to the C-terminal 60 amino acids of the BNYVV coat protein (CP), the 14- and 75-kDa nonstructural proteins, and seven monoclonal antibodies were specific to BNYVV in Western blots. Antisera to the BNYVV CP and to its cloned CP reacted strongly with the 22-kDa CP of the BNYVV isolates but weakly to the 24-kDa CP of the BSBMV related isolates. Antisera to the 42-kDa BNYVV movement protein reacted with the 42-kDa protein of the BNYVV isolates, and also with a ca.44-kDa protein of all but one BSBMV-related isolate. The eight non-BNYVV isolates all gave reactions of identity in Western blots using antisera to the CP of the two original BSBMV isolates from Texas, with a molecular mass of ca.24-kDa, which is distinct from the 22-kDa for the CP al off BNYVV isolates. No cross-reactivity was observed in reciprocal immunodiffusion tests between the CP of BNYVV or the BSBMV isolates, whereas all BNYVV gave reactions of identity to each other and likewise, all BSBMV-related isolates gave reactions of identity to one another. Three BSBMV-like isolates were tested and shown to be transmitted by *Polymyxa betae*. The symptoms of BSBMV isolates were different from those of BNYVV on indicator plants. Three BSBMV-related isolates were analyzed for polyadenylation of the RNA's, and for the size and number of their RNA's in comparison to BNYVV. Like BNYVV, all RNA's of BSBMV-related isolates were polyadenylated, but the size and number of RNA's differed from BNYVV. Based on the various parameters evaluated here, the eight BSBMV isolates appear to be furoviruses, but are distinct from BNYVV.

WRONA, A.F. and R.T. LEWELLEN. Effectiveness of soil solarization, fumigation, and sugarbeet varieties in controlling rhizomania in California's Imperial Valley. J. Sugarbeet Research 31: (in press). 1995.

Rhizomania, a disease that significantly reduces sugar yield of sugarbeet, was first identified in fields in California's Imperial Valley in 1992. A soil-born fungus, *Polymyxa betae*, vectors the causal agent, beet necrotic yellow vein virus (BNYVV). Resting spores remain viable in the soil for more than 20 years. Our primary objective was to evaluate different soil treatments with potential to control rhizomania. We evaluated the performance of four varieties of sugarbeet (both susceptible and partially resistant varieties) in four soil treatments applied to rhizomania-infested soil before planting: 1) solarization (plastic in place for 6 weeks during summer fallow period between crops), 2) fumigation with metam sodium applied at a rate of 60 gal/acre with a three-tiered spray shank, 3) tarped fumigation with methyl bromide/chloropicrin at a rate of 350 lb/acre (chemical control), or 4) untreated control. Each treatment was replicated four times in a completely randomized split plot at the USDA Irrigated Desert Research Station, Brawley, CA. Individual plots were two rows wide by 30 feet long. Beds were on 30" centers and all irrigation was by sprinklers. Differences between soil treatments were highly significant (CI = 95%). Yield expressed as pounds of sugar per

acre was 10,386, 9636, 2676, and 2260 for methyl bromide, solarization, metam sodium and control plots, respectively. Beet tonnage per acre was 33.22, 29.52, 9.49, and 7.99, and percent sucrose was 15.75, 16.37, 13.66, and 13.52 for the respective treatments. Although the resistant varieties yielded more sugar, tonnage, and percent sucrose than the susceptible check, the differences were not significant. The performance of the resistant hybrids may have been reduced because the resistant lines were developed to show resistance specifically to BNYVV, and not to additional edaphic/biotic agents that would have accumulated during the repeated beet cropping done at the site to saturate the ground with viruliferous *Polymyxa betae*.

YU, M.H. <u>Sugarbeet root-knot nematode and approaches taken to develop resistant varieties</u>. J. Sugarbeet Research 31:(in press). 1995.

Sugarbeet is one of the favored hosts of root-knot nematodes. In areas where *Meloidogyne* spp. occur, they can be a serious problem, and in some cases result in a complete crop failure. Observations on nematode life cycles and screening for host plant resistance were conducted in the laboratory and greenhouse. Development of root-knot nematode is marked by the occurrence of four molts and five stages. Nematode feeding stimulated formation of giant cells in host tissues, resulting in root galls and protuberances, thus hindering sugarbeet growth and limiting production. The rate of nematode reproduction was positively associated with the number of root galls formed. Resistance to root-knot nematode is rare; nevertheless, resistance has been identified in *Beta maritima* germplasm. Hybrid crosses were made between the resistant sea beets and sugarbeet. Nematode resistance was transmitted to both the outcrossed and selfed progenies through pollination. Derivative plants with desirable traits are being selected for breeding sugarbeet resistant to root-knot nematode.

PAPERS PUBLISHED SINCE ABSTRACTED IN PREVIOUS REPORT

DUFFUS, J.E., H.Y. LIU, and S. COHEN. <u>Partial characterization of a new closterovirus, the causal agent of cucurbit yellow stunting disorder</u>. Pg. 49 in Sweetpotato Whitefly: 1994 Supplement to the Five-Year Plan, U.S. Dept. Agr. ARS No. 112. 1994.

DUFFUS, J.E., H.Y. LIU, and G.C. WISLER. <u>A new closterovirus of tomato in souther California transmitted by the greenhouse whitefly (*Trialeurodes vapararriorum*)</u>. Phytopathology. 84:1072-1073. 1994.

DUFFUS, J.E., H.Y. LIU, and G.C. WISLER. <u>Lettuce chlorosis virus--A new whitefly-transmitted closterovirus in the southwest</u>. Phytopathology. 84:1168. 1994.

Beet necrotic yellow vein virus and its relationship to eight sugar beet furo-like viruses from the U.S.A.

G. C. Wisler, H.-Y. Liu, and J. E. Duffus, USDA/ARS Sugar Beet Research Station, 1636 E. Alisal St., Salinas, CA 93905.

ABSTRACT

The degree of relatedness among five beet necrotic yellow vein virus (BNYVV) isolates and eight other rigid, rod-shaped viruses coined beet soil-borne mosaic virus (BSBMV) isolated from sugar beet roots from the U.S.A. was evaluated by serology, electron microscopy, fungal transmission, the polymerase chain reaction (PCR), and host range. Polyclonal antisera to the C-terminal 60 amino acids of the BNYVV coat protein (CP), the 14- and 75-kDa nonstructural proteins, and seven monoclonal antibodies were specific to BNYVV in western blots. Antisera to the BNYVV CP and its cloned CP reacted strongly with the 22-kDa CP of the BNYVV isolates, but weakly with the 24-kDa CP of the BSBMV. Antisera to the 42-kDa BNYVV nonstructural protein reacted with a 42-kDa protein of all BNYVV isolates and with a 44-kDa protein of all but one BSBMV isolate. No cross-reactivity was observed in reciprocal immunodiffusion tests between BNYVV and the BSBMV isolates using antisera to the CP of each virus. No products were observed for the BSBMV isolates analyzed in PCR using 10 BNYVV primer pairs. The eight BSBMV isolates investigated induced symptoms different from those of BNYVV in several hosts. Two BSBMV isolates tested were transmitted by *Polymyxa betae*. These eight BSBMV isolates appear to be furoviruses distinct from BNYVV.
Additional keywords: Rhizomania, *Beta vulgaris*, soil-borne virus, fungal vector.

INTRODUCTION

Beet necrotic yellow vein virus (BNYVV), which induces symptoms of rhizomania in sugar beet (*Beta vulgaris* L.), was first detected in the U.S. in 1983 (9). It is a member of the furovirus group, with a rigid rod-shaped particle morphology, and is transmitted by *Polymyxa betae* Keskin (19,24). Characteristics of rhizomania include "bearding" or proliferation of lateral roots and a loss both in yield and sugar production (5,7). Control measures for BNYVV include the use of resistant sugar beet varieties and selective planting in soil found to be free of BNYVV based on ELISA tests.

Most isolates of BNYVV typically contain four single-stranded 5'-capped and 3'-polyadenylated plus-sense molecules (18). All four RNAs have been cloned and sequenced (2,3,4). RNA-1 encodes a single open reading frame (ORF) of a 237-kDa nonstructural protein with helicase and replicase motifs (16). RNA-2 encodes the coat protein ORF of ca. 22-kDa, in addition to a readthrough product with a theoretical molecular weight of

75-kDa, and four additional nonstructural proteins of 42-kDa, 13-kDa, and 15-kDa which are involved in cell-to-cell movement (19). The function of the 14-kDa protein encoded by RNA-2 has not been fully determined. RNA-3 and RNA-4 encode a single ORF each of 25-kDa and 31-kDa, respectively. The 25-kDa protein is associated with leaf symptoms and root proliferation (11), and the 31-kDa protein is essential for fungal transmission (23).

Eight other virus isolates with rigid, rod-shaped particle morphologies similar to BNYVV have been isolated from sugar beet roots in the U.S., and will be referred to herein as beet soil-borne mosaic virus (BSBMV, 14). Two were isolated from Texas (BSBMV-1 and -2), five from Nebraska, and one from Idaho. These isolates have been shown to cross-react with antisera to the BNYVV virion in ELISA and in western blot analyses (29,30). The effect of these virus isolates on sugar beet is not fully known. In this study serological analyses of both structural and nonstructural proteins, electron microscopy, fungal transmission, reverse-transcriptase polymerase chain reaction (RT-PCR), and host range analyses were used to investigate the relationship among five BNYVV isolates, and the relationship between the BNYVV isolates and the eight BSBMV isolates described above.

MATERIALS AND METHODS

Virus isolates. The BNYVV isolates addressed in this study originated from sugar beet fields in California (BNYVV-CA-1, BNYVV-CA-12, and BNYVV-CA-GH), Nebraska, (BNYVV-NE-8-4), and Idaho (BNYVV-ID-47). The BNYVV-CA-GH was the original U.S. isolate found in California and has been maintained by continuous mechanical inoculation on *Beta macrocarpa* Guss for several years in the greenhouse. Two BSBMV isolates originated from Texas (BSBMV-1 and -2), five from Nebraska (NE-8-1, NE-8-3, NE-8-5, NE-10, NE-KW), and one from Idaho (ID-31051). Both BNYVV and BSBMV isolates were initially obtained by mechanical inoculation from infected roots and symptomatic leaf tissues collected from field samples onto leaves of *Chenopodium quinoa* Willd. and *B. macrocarpa* plants. Isolates derived from single local lesions were increased in *C. quinoa* and stored by lyophilization and in glycerol at -20 C.

Electron microscopy. Leaf extracts were prepared for examination with the electron microscope by chopping tissue with a razor blade into 0.01 M potassium phosphate buffer, pH 7.0, at a ratio of approximately 1 part tissue to 5 parts buffer. One drop of extract was placed onto a 0.4% formvar coated copper grid for 1 min, followed by 20 drops of buffer, 20 drops of water, and a final drop of 2% uranyl acetate containing 250 μg/ml bacitracin. Purified preparations of virus isolates were examined by

placing 10 μl (ca. 0.1 mg/ml) onto a grid followed by rinsing and staining as described.

Fungal transmission. Two separate experiments were performed to test for fungal transmission. The experimental design was similar in both tests, but in the first experiment *B. vulgaris* was the host plant, and in the second experiment *B. macrocarpa* was used. Holes were drilled in the bottom of 50 ml disposable centrifuge tubes. The tubes were plugged with two layers of cheesecloth, filled with builders' sand, and autoclaved. Seed of each host were surface sterilized and planted into each tube, approximately 10 seeds per tube. Two weeks after planting, when two to four leaves had fully expanded, the leaves were mechanically inoculated with either BNYVV, BSBMV-2, NE-10, or 0.1 M potassium phosphate buffer, pH 7.2. For each treatment above, three tubes were inoculated with a fresh root sample containing mature cystosori of *P. betae*. This root culture of *P. betae*, originally collected from a rhizomania-free sugar beet field, was routinely tested and determined to be free of BNYVV, BSBMV, and tobacco mosaic virus (TMV), a common contaminant in sugar beet roots. A second set of three tubes from each treatment was not inoculated with *P. betae*. Plants were placed in a growth room at 20 C constant temperature with a 16 hr daylength at 50 $\mu E \cdot m^{-2} \cdot s^{-1}$.

After two to three weeks, root samples from each tube were examined with the light microscope. Those seedlings which had been inoculated with *P. betae* contained mature cystosori. Those seedlings which had not been inoculated with *P. betae* did not contain any visible cystosori. At this time, each tube was secured above another tube of 2 week old healthy seedlings which were grown in the same manner. As the top donor tubes were watered, they were allowed to drip into the bottom recipient tubes. The cheesecloth plug in the tubes allowed zoospores to filter through to the recipient tubes, excluding pieces of plant material. After two months, all roots were harvested, assayed for BNYVV and BSBMV by western blot analysis, and used to mechanically inoculate leaves of *C. quinoa* and *B. macrocarpa*.

Serological analyses. The double-antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) was done as described by Clark and Adams (8), with an immunoglobulin concentration of 1 μg/ml for coating the ELISA plates and a 1000-fold dilution of the alkaline phosphatase conjugates. Plant extracts were obtained by macerating one part plant tissue in three parts of sample extraction buffer (0.1 M phosphate buffered saline, pH 7.4, with 2% polyvinylpyrrolidone and 0.2% ovalbumin). Root samples were derived from sugar beet (cv. USH11) seedlings grown in soil samples submitted from sugar beet fields. Healthy samples consisted of sugar beet seedlings grown in autoclaved soil. Samples were tested in

pairs and the average absorbance at 405 nm was recorded. Samples determined to be positive had average ELISA values which were three times the average healthy readings.

The western blot procedure was conducted essentially as described by Towbin et al. (27) using a Bio-Rad Mini-Protean II Electrophoresis Cell and Trans-Blot Electrophoretic Transfer Cell (Hercules, CA) according to manufacturer's instructions. In most instances, 12 and 15% sodium dodecyl sulfate-polyacrylamide (SDS-PAGE) gels were used. Plant tissues selected for assay were triturated in an extraction buffer (1:2, w:v) consisting of 75 mM Tris-HCl, pH 6.1, 9 M urea, 7.5% 2-mercaptoethanol, and 4.5% SDS (21). Samples were squeezed through dampened cheesecloth, heated at 95 C for 2 min, and centrifuged at 10,000 X g for 2 min. Extracted samples were stored at -20 C. Each isolate was tested at least twice in both *B. macrocarpa* and *C. quinoa*.

In western blots, polyclonal antisera and monoclonal ascites were routinely diluted 1/1000 and monoclonal tissue culture supernate at 1/10. Antisera to the C-terminal 60 amino acids of the BNYVV capsid protein and the 14-, 25-, 42-, and 75-kDa nonstructural proteins (16) were kindly supplied by K. Richards, (Strasbourg, France). The BNYVV monoclonal antibodies (MAbs) 41 and 47 (10) were supplied by G. Grassi (Bologna, Italy), and MAbs 6,7,8,9, and 10 (26) were supplied by L. Torrance (Dundee, U.K.). Antisera also was produced in this study to the BNYVV coat protein (CP) which was cloned (clone courtesy of K. Richards) and expressed in the pETh vector (15) with BL21DE3pLysS as the *E. coli* expression host (Novagen, Madison, WI).

Sodium dodecyl sulfate (SDS)-immunodiffusion tests were conducted as described by Purcifull and Batchelor (17). Immunodiffusion media consisted of 0.8% Noble agar, 0.5% sodium dodecyl sulfate (SDS), and 1% NaCl, and 0.05 M Trizma base, pH 8.0 (31). Antigens in leaf extracts of *C. quinoa* were prepared 1:1 (w:v) in 1.5% SDS. Purified virus preparations (ca. 0.1 mg/ml) were used 1:1 (v:v) in 3% SDS. All isolates were tested at least twice against antisera to both BNYVV, BSBMV-1, and BSBMV-2 using plant tissue as the antigen. In addition, selected isolates were tested as purified virus preparations.

Host plant inoculations. Test plants used for inoculations were held in the dark for 16-24 h prior to inoculations. Initial virus inoculations were made by triturating sugar beet root tissues in a mortar and pestle with 0.1 M potassium phosphate buffer, pH 7.2, containing 0.1% Na_2SO_3, with the addition of 600 mesh carborundum. The slurry was rubbed onto leaves, and plants were rinsed gently with water after inoculation. Test plants included *B. vulgaris, B. macrocarpa, C. quinoa, C. murale L., C. amaranticolor* Coste & Reyn., *C. capitatum* L (Asch.), *Spinacea oleracea* L., *Gomphrena globosa* L., *Nicotiana benthamiana* Domin, *N. glutinosa* L., and *N. tabacum* L.

Three successive single local lesion transfers were made with each new isolate to be sure of purity and escape possible contamination with TMV, commonly found in sugar beet roots. Host plant studies were repeated three times.

RT-PCR. Aliquots of purified virus preparations (ca 0.1 mg/ml) were subjected to a phenol:chloroform extraction, followed by an ethanol precipitation. The extracted viral RNA was used as a template for production of cDNA using reverse transcriptase (Superscript, Gibco BRL, Grand Island, NY), followed by amplification by PCR as described by Robertson et al. (20). Briefly, the RNA was resuspended in 10 µl of water treated with diethyl pyrocarbonate (DEPC), and was added to 50 pmol of the RNA-specific primers (primers 1, 4, 7, 13, CP-1, or 42k-1, Table 1) to a final volume of 12.5 µl. This was heated to 95 C for 5 min, then cooled to 40 C for 10 min. The annealed template was added to the first strand reaction mixture consisting of 200 U Superscript II RNase H⁻ (Gibco.BRL, Grand Island, NY) and 2.5 mM dNTPs, in a final volume of 25 µl for 1 hr at 37 C. The first strand buffer and dithiothreitol (DTT) were used according to manufacturers' instructions. cDNA samples were frozen or used directly in the PCR reaction. One isolate from each state was chosen for RT-PCR analysis (BNYVV-CA-1, -NE-8-4, and -ID-47), in addition to the original greenhouse isolate from California (BNYVV-CA-GH). The complete RT-PCR reactions were conducted a minimum of three times. Primers were prepared according to the published sequence of BNYVV (2,3,4,22) to represent the 5'- and 3'- regions of RNA-1, -2, -3, and -4 (courtesy C. Rush), and to include the CP gene and the 42-kDa protein-encoding gene of RNA-2 (19). For primer sequences and location on the BNYVV genome, see Table 1. PCR reactions were performed in a final volume of 100 µl with one unit of Taq polymerase (Promega, Madison, WI). The amplification profile included: 94 C for 3 min, 45 C for 1 min, 72 C for 3 min (three cycles), 93 C for 1 min, 45 C for 1 min, 72 C for 3 min (35 cycles), and 72 C, 10 min (1 cycle). PCR products were analyzed on a 1.0% agarose gel and a 6% acrylamide gel, stained with 0.5 mg/ml ethidium bromide, and viewed with ultraviolet light.

RESULTS

Electron microscopy. All of the isolates addressed in this study, including those identified as BNYVV and those which were serologically identical to BSBMV-1 and -2 contained rigid, rod-shaped virus particles with a central core as shown in Fig. 1. The virus particles were 20 nm wide and consisted of varying lengths, seen in both leaf dips and purified preparations.

Fungal transmission. In both experiments, the roots from plants which were mechanically inoculated with BNYVV, BSBMV-2 or NE-10 gave

Table 1. Primers used in RT-PCR analyses of BNYVV and BSBMV isolates.

Primer; Direction of Synthesis	Sequence[a]	Nucleotide position on RNA
primer 1; 3' to 5'c	5'-TTCACCCAGTCAGTA-3'	6,704/RNA-1; 4,574/RNA-2; 1,735/RNA-3; 1,391/RNA-4b
primer 2; 5' to 3'	5'-TTTGTCTGATGCTATTG-3'	465/RNA-1
primer 3; 5' to 3'	5'-AGATAGTGCTATAAACGG-3'	5,649/RNA-1
primer 4; 3' to 5'	5'-CACTTCCATATATTGCGG-3'	1,029/RNA-1
primer 5; 5' to 3'	5'-CTGCGAATCTATCTATTATAA-3'	275/RNA-2
primer 6; 5' to 3'	5'-AACTTAAATGCAAGAAAC-3'	4,263/RNA 2
primer 7; 3' to 5'	5'-CGTACATTAGCAGATGC-3'	484/RNA-2
primer 8; 5' to 3'	5'-ACAGCCGGTTACATGGT-3'	1,501/RNA-3
primer 11; 5' to 3'	5'-GTTCTGTTGAGATTCT-3'	111/RNA-4
primer 12; 5' to 3'	5'-GTTGGACGTGTACGTGT-3'	587/RNA-4
primer 13; 3' to 5'	5'-AACCTGACACCGACATA-3'	360/RNA-4
primer CP-1; 3' to 5'	5'-ATGTCGAGTGAAGGT-3'	145/RNA-2
primer CP-2; 5' to 3'	5'-CTATTGTCCGGGTGG-3'	711/RNA-2
primer 42k-1; 3' to 5'	5'-ATGGTCCAAGTACAG-3'	2,133/RNA-2
primer 42k-2; 5' to 3'	5'-CGCAAAAAGTATCTC-3'	3,276/RNA-2

aSequences are derived from those reported for BNYVV by Bouzoubaa et al., 1985, 1986, and 1987.

bThe sequence for primer 1 corresponds to a conserved sequence at the 3'-end of each of RNA's-1, -2, -3, and -4.

cPrimers that were used as pairs were: 1&3, 1&6, 1&8, 1&11, 1&12, 2&4, 5&7, 11&13, CP-1&CP-2, 42k-1&42k-2.

positive reactions in western blots for the respective viruses. For example, roots from BNYVV mechanically inoculated plants showed a positive reaction at ca. 22-kDa using BNYVV antiserum, whereas BSBMV-2 and NE-10 inoculated plants were positive for BSBMV-2 at ca. 24-kDa. Plants which were inoculated with buffer only were negative in western blots for both BNYVV and BSBMV-2. Two to three weeks after inoculation with *P. betae*, roots were found to contain numerous cystosori, whereas no cystosori were observed in those plants which had not been inoculated with *P. betae*.

The bottom, recipient plants which had received leachate from the *P. betae* and virus-inoculated donor plants also became infected with the respective virus. Those plants which had received leachate from virus infected donor plants without *P. betae* were not infected with either virus. Plants which had received leachate from either *P. betae* alone or buffer treated donor plants were likewise not infected with either virus. Infections were confirmed by both western blot analyses and mechanical inoculations onto *C. quinoa* and *B. macrocarpa*.

Serological analyses. Weak cross-reactivity was seen in ELISA tests between BNYVV, and BSBMV-1 and -2 (Table 2). Homologous reactions were greater than three times the healthy mean $O.D._{405}$ reading, whereas heterologous readings often ranged from approximately two to three times the healthy mean.

Table 2. Absorbance values for BNYVV, BSBMV-1 and -2 in DAS-ELISA.

| Isolates | Antisera | | |
	BNYVV	BSBMV-1	BSBMV-2
BNYVV-CA-1	0.815[a] (7.8x)[b]	0.206 (2.2x)	0.315 (2.0x)
BSBMV-1	0.209 (2.0x)	0.877 (9.1x)	0.997 (6.2x)
BSBMV-2	0.269 (2.6x)	0.719 (7.5x)	1.223 (7.6x)
Healthy	0.105	0.096	0.161

[a] A_{405} values reflect the average of two replications and are representative of the cross-reactivity seen between BNYVV and BSBMV isolates found outside of California. DAS -ELISA tests were made at 1 μg/ml coating immunoglobulin and 1000-fold dilution of alkaline phosphatase conjugate.

[b] Numbers in parentheses are the ratio of the average A_{405} values for each sample to its respective healthy control.

Results from western blot analyses are summarized in Table 3. Antisera to the whole CP of BNYVV and to the cloned CP of BNYVV reacted strongly at ca. 22-kDa with the five BNYVV isolates tested (Fig. 2A). These same antisera reacted weakly, however, with all eight of the BSBMV isolates at ca. 24-kDa. Reciprocal tests in western blots were made using

antisera to the CP of the BSBMV isolates -1 and -2 from Texas. Both antisera reacted strongly with all eight of the BSBMV isolates at ca. 24-kDa, but reacted weakly with the five BNYVV isolates at ca. 22-kDa. Antiserum to the C-terminal 60 amino acids of the BNYVV capsid protein was specific to BNYVV and reacted exclusively with the five BNYVV isolates at ca. 22 kDa (Fig. 2B).

Antisera to the nonstructural 75-kDa and 14-kDa proteins of BNYVV likewise reacted in western blots only with the five BNYVV isolates, at 75-kDa (Fig. 2C) and 14-kDa, respectively. Antisera to the 25-kDa BNYVV nonstructural protein reacted with two BNYVV isolates from California (BNYVV-CA-1 and -12), and with one from Nebraska (BNYVV-NE-8-4), but not with an isolate of BNYVV from Idaho (BNYVV-ID-47) or with an isolate from California that had been maintained in a greenhouse by mechanical inoculation for several years (BNYVV-CA-GH). All seven BNYVV MAbs reacted specifically to the BNYVV isolates, but not to any of the BSBMV isolates. Only the antiserum to the BNYVV 42-kDa nonstructural protein reacted strongly with all BNYVV isolates and with all but one BSBMV isolate (NE-KW). In this western blot, the BNYVV isolates reacted with a MW of ca. 42-kDa, whereas the seven BSBMV isolates reacted with a MW of ca. 44-kDa.

No cross-reactivity was observed in reciprocal SDS-immunodiffusion tests between any of the five BNYVV isolates and the eight BSBMV isolates. Reactions of identity were observed among all BNYVV isolates when tested against BNYVV antiserum (Fig. 3). Likewise, reactions of identity were observed among all eight BSBMV isolates when tested against antisera to either BSBMV-1 or BSBMV-2. Reactions using purified virus preparations were stronger than those using plant extracts as the antigens (data not shown), but the same specificity was consistently seen in each case.

Host range studies. All BNYVV isolates induced similar symptoms on the indicator plants tested. These reactions included characteristic chlorotic to bright yellow local lesions which spread into the veins in *C. quinoa*. All five BNYVV isolates also produced yellow local lesions on *B. macrocarpa* and sugar beet, with systemic vein clearing and distortion on *B. macrocarpa*.

The BSBMV isolates from sugar beet induced reactions on the indicator plants distinct from those of BNYVV and varied according to the isolate (Table 4). For example, symptoms on *C. quinoa* ranged from diffuse, chlorotic local lesions with BSBMV isolates -1 and -2, to necrotic local lesions for isolates NE-10 and NE-KW. Symptoms on *B. macrocarpa* ranged from necrotic local lesions for NE-8-1 to a systemic necrosis of the midrib veins for ID-31051 and NE-8-3. No infection was detected when either BNYVV or BSBMV isolates were mechanically inoculated onto plants of *Nicotiana benthamiana* Domin, *N. glutinosa* L., or *N. tabacum* L.

Table 3. Summary of western blot analyses of sugarbeet furoviruses using antisera to structural and nonstructural proteins of BNYVV, and to BSBMV-1 and BSBMV-2.

Isolates	Antisera[a]							
	BNYVV coat protein -1 & 2	BNYVV coat protein/C-terminus	BSBMV	BNYVV anti-P75	BNYVV anti-P42	BNYVV anti-P14	BNYVV anti-P25	BNYVV MAbs 41,47 6-10
BNYVV isolates								
BNYVV-CA-GH	+,22k[b]	(+,22k)	+,22k	+,75k	+,42k	+,14k	-	+,22k
BNYVV-CA-1	+,22k	(+,22k)	+,22k	+,75k	+,42k	+,14k	+,25k	+,22k
BNYVV-CA-12	+,22k	(+,22k)	+,22k	+,75k	+,42k	+,14k	+,25k	+,22k
BNYVV-NE-8-4	+,22k	(+,22k)	+,22k	+,75k	+,42k	+,14k	+,25k	+,22k
BNYVV-ID-47	+,22k	(+,22k)	+,22k	+,75K	+42k	+,14k	+,25k	+,22k
BSBMV isolates								
NE-8-1	(+,24k)[c]	+,24k	+,24k	-	+,44k	-	-	-
NE-8-3	(+,24k)	+,24k	+,24k	-	+,44k	-	-	-
NE-8-5	(+,24k)	+,24k	+,24k	-	+,44k	-	-	-
NE-10	(+,24k)	+,24k	+,24k	-	+,44k	-	-	-
NE-KW	(+,24k)	+,24k	+,24k	-	-	-	-	-
ID-31051	(+,24k)	+,24k	+,24k	-	+,44k	-	-	-
BSBMV-1	(+,24k)	+,24k	+,24k	-	+,44k	-	-	-
BSBMV-2	(+,24k)	+,24k	+,24k	-	+,44k	-	-	-
Noninoculated hosts								
C. quinoa	-[d]	-	-	-	-	-	-	-
B. macrocarpa	-	-	-	-	-	-	-	-

a Antisera to nonstructural proteins are courtesy of K. Richards; to monoclonal antibodies (MAbs) 41 and 47 courtesy of G. Grassi, and MAbs 6,7,8,9, and 10 courtesy of L. Torrance.

b k=kilodaltons; values reported are estimates of the protein molecular weights based on known protein standards.

c parentheses indicate a weak heterologous reaction, unlike the strong homologous reaction.

d - = no detectable reaction

Table 4. Selected host range and symptoms of eight beet soil-borne mosaic furovirus isolates.

Host Plants	BSBMV Isolates[a]							
	NE 8-1	NE 8-3	NE 8-5	NE-10	NE-KW	ID-31051	BSBMV-1	BSBMV-2
Beta vulgaris	chl ringspot	chl LLb	chl LL	nec LL	chl ringspot	chl ringspot	sys mos	sys mos
B. macrocarpa	nec LL	nec LL & sys nec	nec LL & sys mos	nec LL & sys mos	nec LL	nec LL & sys nec	nec LL & sys mos	sys mos
C. quinoa	chl LL	chl LL	chl LL	nec LL	nec LL	chl LL	chl LL	chl LL
C. murale	nec LL & sys mos	nec LL	chl LL	nec LL	nec ringspot	chl LL	chl LL	nr
C. amaranticolor	chl LL	chl LL	chl LL	nec LL	nec LL	chl LL	chl LL	nr
C. capitatum	nec LL	nec LL & sys mos	chl LL	nec LL & sys nec	nec LL	nec LL	chl LL	nr
S. oleracea	nr	sys mottle	chl LL	chl LL	sys mottle	nr	nr	nr
G. globosa	nr	nec LL	nr	nr	nr	nr	nr	nr

a NE =Nebraska, ID =Idaho, BSBMV =beet soil borne mosaic virus isolates from Texas.
b chl =chlorotic, LL = local lesion, nec=necrotic, sys mos =systemic mosaic
nr =no reaction

RT-PCR analyses. Products observed in repeated RT-PCR analyses among the four BNYVV isolates tested were identical for RNA-1 (primer pairs 1&3 and 2&4), RNA-2 (primers 1&6, 5&7, CP, and 42-kDa protein), and RNA-3 (primers 1&8, Fig. 4). The products for RNA-4 of the BNYVV isolates (primers 1&12 and 1&11) were not identical. Primers 1 and 12, which amplify the 3' region of RNA-4, showed two or three major products depending on the BNYVV isolate indicating possible mispriming. Primers 1 and 11, which amplify most of the full length of RNA-4, produced a ca. 750 bp product for the greenhouse isolate of BNYVV (CA-GH), and a ca. 1100 bp product for the BNYVV isolates, CA-1, NE-8-4, and ID-47. The PCR products obtained for RNA-1, -2, and -3 were similar to the expected sizes based on the published sequences (2,3,4) in each case. Primer pair 1 and 8, which corresponds to the 3'-end of RNA-3, gave a very faint reaction for BNYVV-CA-GH. This corresponds to western blot data where BNYVV-CA-GH did not react with antisera to the 25-kDa protein encoded by RNA-3. In addition to the expected products observed for primers representing the CP (ca. 550 bp) and the 42-kDa-encoding genes (ca. 1100 bp), each primer pair produced a smaller sized product of ca 240 bp and 260 bp, respectively, indicating possible mispriming in those regions (Fig. 4).

No distinct products were detected using any of the BNYVV primer pairs for BSBMV-1, -2, or for a related BSBMV isolate from Nebraska, NE-10. In some cases, a smear was observed or faint multiple bands indicating a possible lack of specificity.

DISCUSSION

Based on reciprocal cross-reactivity in western blots using whole virus CP antisera, BNYVV is related to, but distinct from the BSBMV isolates addressed in this study. Antisera to the cloned CP of BNYVV expressed in and purified from *E. coli* showed the same cross-reactivity as the antisera to the purified BNYVV virion, confirming the results obtained with whole virus antisera. Antisera to the C-terminus of the BNYVV coat protein, however, was specific to BNYVV and did not cross-react with the BSBMV isolates. Ward and Shukla have reported similar results for potyviruses (28), where antisera to the N-or C- termini of the coat protein are highly specific, whereas antisera to the core are cross-reactive. The 42-kDa antisera was also cross-reactive among all but one BSBMV isolate (NE-KW) used in this study. This result is not surprising, because the 42-kDa protein is conserved among several plant virus groups, including potex-, carla-, furo-, and hordeiviruses (1) and has been implicated in cell-to-cell transport. All seven BNYVV MAbs used in this study were specific to the five BNYVV isolates tested from the U.S. Four of the MAbs supplied by L. Torrance (MAb 6,7,8, and 9) also reacted with all 19 European BNYVV isolates tested (26). The cross-reactivity between BNYVV and BSBMV isolates seen in western blots and ELISA using antisera to the

respective coat proteins was not seen in the immunodiffusion tests, probably due to the lower sensitivity of this test.

The similarity among BNYVV isolates to one another in serological tests was likewise noted for products obtained for the RNA-1, -2, and -3 in RT-PCR. The variation in the PCR products seen in this study for RNA-4, however, is not surprising, given that it has been reported to be more diverse in size among previously tested isolates (6,12,25). Variation in the presence or level of expression of RNA-3 was seen in western blot analyses of its 25-kDa protein, the product of which was not detected in the BNYVV isolates CA-GH and ID-47. A study by Lemaire et al (13) indicated that, although RNA-3 and -4 may not be detected, they can reappear after isolates of BNYVV are successfully transmitted to sugar beets via *P. betae.* Thus, these RNAs may exist at extremely low levels after repeated mechanical transmission. A relationship between the BNYVV isolates and BSBMV-1, -2, and NE-10 was not observed in the RT-PCR analyses.

The eight BSBMV isolates addressed in this study are not known to be responsible for the rhizomania disease symptomatology, and in host range studies induced symptoms distinct from those observed for BNYVV. However, the effect of these virus isolates on sugar beet production is not fully known. These isolates have been grouped together in this study because of their reactions of identity with BSBMV-1 and -2 in immunodiffusion tests and their identical MW to one another (ca. 24-kDa) in western blots. Transmission experiments using isolates BSBMV-2 and NE-10 indicate both of these to be transmitted by *P. betae.* The cross-reactivity seen in western blots between the eight BSBMV isolates with the BNYVV CP and 42-kDa protein antisera, the MW of the CP (24-kDa), the rigid rod-shaped particle morphology, and transmission by *P. betae* indicate that these isolates belong to the furovirus group, but are distinct from BNYVV. Whereas the five BNYVV isolates caused similar symptoms on respective indicator plants, the eight BSBMV isolates produced a variety of different symptoms on the host range studied. These eight BSBMV isolates thus appear to be biologically more diverse than the BNYVV isolates studied.

It is possible, in sensitive serological tests such as ELISA or western blots, using antisera to the whole virion of BNYVV, that false positive results could occur due to the presence of one or more of the related furoviruses of sugar beet. Since BNYVV is an important pathogen of sugar beet, and subject to quarantine restrictions, these relationships could cause unnecessary regulatory problems for the sugar beet industry. Although western blot analysis is not well suited to large scale diagnostic tests, with the proper controls, it can distinguish between BNYVV and the other rigid, rod-shaped isolates addressed in this study. To date, no isolate similar to the BSBMV-1 or -2 has been detected from California. Future studies will

focus on the genomic characterization of the eight furoviruses addressed in this study and to determine their effect on, and importance to, the sugar beet industry.

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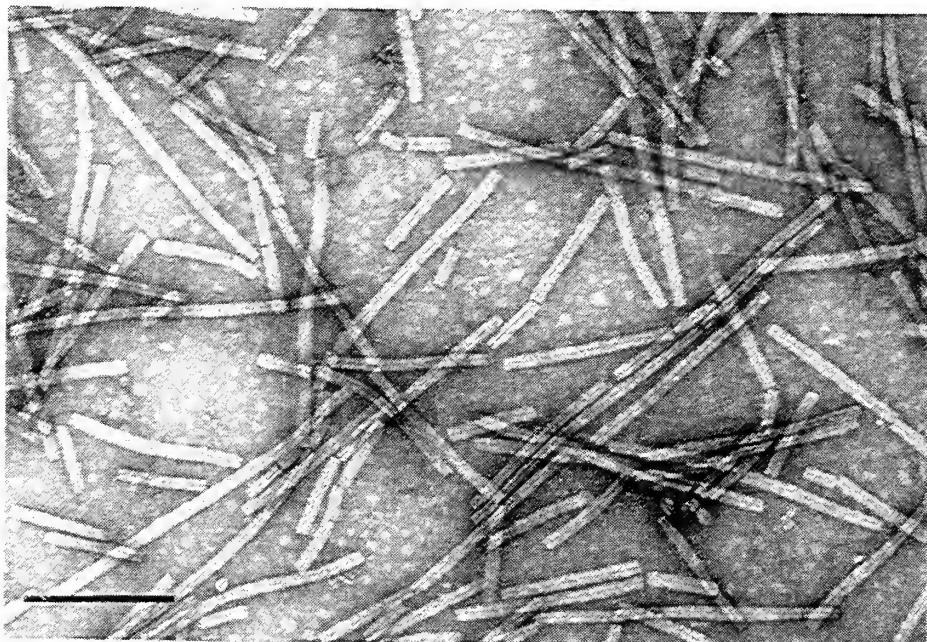
Fig.1. Electron micrograph of a partially purified preparation of beet soil-borne mosaic virus -1 stained with 2% uranyl acetate. Bar represents 200 nm.

Fig. 2. Western blot analyses of five BNYVV isolates and eight BSBMV-related furovirus isolates (NE-KW, NE 8-1, NE 8-3, NE 8-5, NE-10, ID 31051, BSBMV-1, and -2). All isolates were tested against (A) polyclonal antiserum to the purified BNYVV virion, (B) polyclonal antiserum to the C-terminal 60 amino acids of the CP of BNYVV which was cloned and expressed in *E. coli*, (C) polyclonal antiserum to the BNYVV 75-kDa nonstructural protein. Healthy lane refers to noninoculated *C. quinoa* tissue. Molecular weight standards (MW) standards, in kilodaltons (kDa) are: phosphorylase b (97), bovine serum albumin (68), ovalbumin (43), carbonic anhydrase (29), b-lactoglobulin (18). Arrows indicate approximate MW of respective protein.
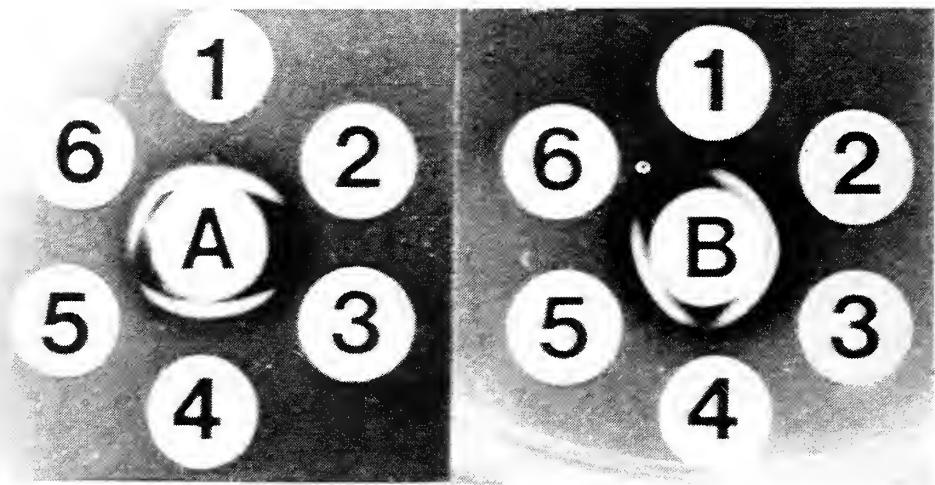
Fig. 3. Sodium dodecyl sulfate (SDS)-immunodiffusion tests with BNYVV and BSBMV-2. Reactions shown are using purified virus extracts (ca. 0.1 mg/ml) as the antigen. Samples are (1) BNYVV-CA-1, (2) BSBMV-1, (3) BSBMV-2, (4) BNYVV-NE-8-4, (5) NE-10 (serologically identical to BSBMV isolates), and (6) BNYVV-ID-47, prepared 1:1 with 3% SDS. Antisera are: (A) polyclonal antisera made to the cloned capsid protein of BNYVV and (B) polyclonal antisera made to the purified BSBMV-2 virion.
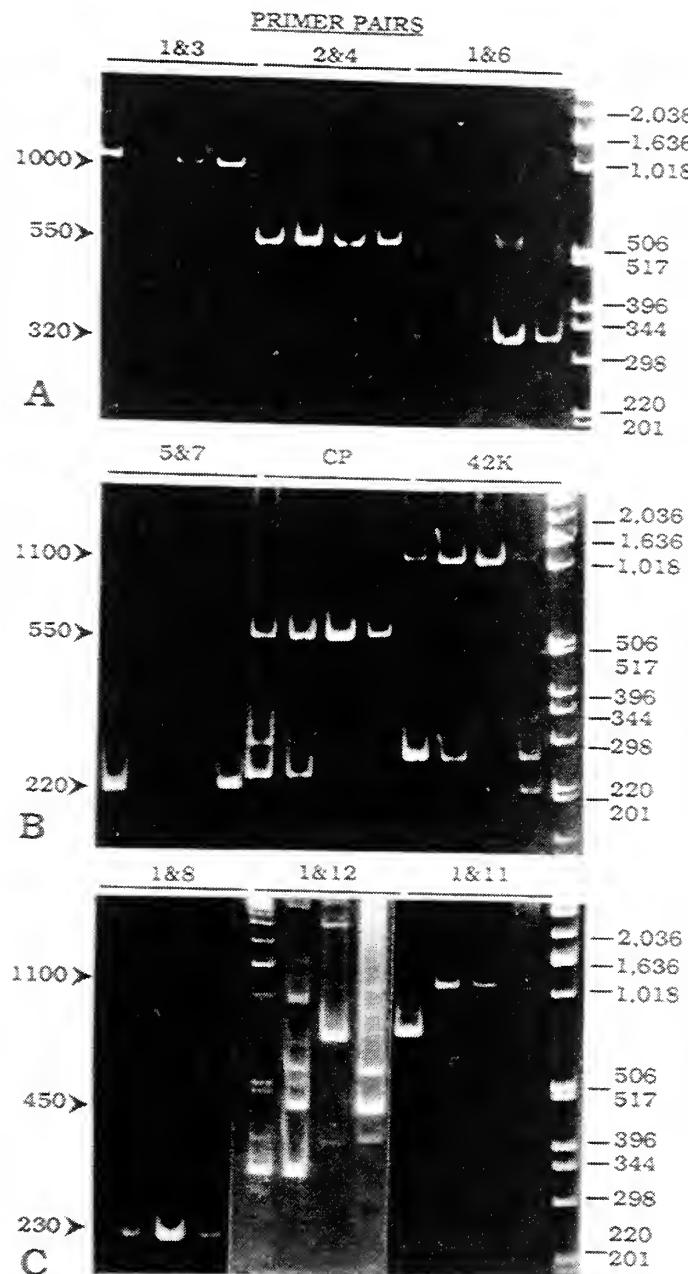
Fig. 4. Results from RT-PCR analysis using primers specific to BNYVV. Primer pairs are indicated above each of four BNYVV isolates, two from California (CA), and one each from Nebraska (NE), and Idaho (ID). Each group of four reactions is indicated by the primer pair tested. Each isolate is shown in the same order for each primer pair tested as: BNYVV-CA-GH, BNYVV-CA-1, BNYVV-NE-8-4, and BNYVV-ID-47. Primer pairs 1&3, and 2&4 represent regions of RNA-1. Primer pairs 1&6, 5&7, capsid protein (CP), and 42K represent regions of RNA-2. Primer pairs 1&8 represent a region of RNA-4, and pairs 1&12 and 1&11 represent RNA-4. Primers 1&11 represent most of the full-length of RNA-4 (941 bp). Standards are the 1KB DNA ladder (BRL, Gaithersburg, MD). Arrows and respective values, in bp, indicate the approximate sizes of the major products obtained for each primer pair tested.

DEVELOPMENT OF SUGARBEET BREEDING LINES AND GERMPLASM

R. T. LEWELLEN

BREEDING LINES C78, C80NB, C80, C80-45, and C82NB - These multigerm, open-pollinated breeding lines were released in 1994. They should combine sources of resistance or tolerance to rhizomania (Rz), virus yellows, nonbolting, curly top, Erwinia, and powdery mildew with adaptation to the far West. All are derived from base populations developed in the virus yellows and multiple disease resistance program at Salinas.

C78 is a near-isoline of C46/2. It is from a backcrossing series where BC_1 through BC_3 were made to C46/2. C37 was used for the first cross to the Holly hybrid Rz source. Following BC_3, the line was increased five times. For three of these increases, recurrent phenotypic selections for resistance to rhizomania were made, including one cycle of selection for combined resistance to rhizomania, virus yellows caused by beet yellows and beet western yellows viruses, Erwinia root rot caused by E. carotovora (Jones) Bergey et al. subsp. betavasculorum Thomsen et al., and powdery mildew caused by Erysiphe polygoni DC. The final cycle of selection was for resistance to bolting. From 12 month old plants in an overwintered planting, nonbolted plants were selected. Within these nonbolted beets, a final reselection was made based upon individual root sucrose concentration. C78 has been evaluated as breeding lines similar to R478NB, R478, R378, R278, R278Y, and R078.

C80NB is a near-isoline of C54/2. Except for the choice of the recurrent parent, the selection procedure was the same as for C78. C80NB is being tested as breeding line R480NB. It was tested during development as breeding lines R380, R280, R280Y, and R080.

C80 is similar to C80NB but underwent a different selection procedure for the last two cycles of selection. Starting with the second cycle synthetic following the backcross procedure that lead to C80NB, half-sib families were generated. Ninety-six of these families were tested for yield at Salinas in trials grown under nondiseased, virus yellows infected, Erwinia inoculated/ powdery mildew infected, and rhizomania conditions. Based upon results from these tests, eight families were selected and topcrossed onto a common monogerm tester and evaluated for general combining ability. The second synthesis of each of these eight half-sib families was planted into a field infested with rhizomania and at 3 months of age inoculated with Erwinia. At 7 months, mother roots from within five of the families were selected based upon resistance to rhizomania and Erwinia and then reselected based upon sugar concentration. These roots were combined and increased in isolation to produce C80. C80 has been evaluated as breeding lines R480-#, R280-#'s, R080, and R980.

C80-45 was increased from mother roots from family R280-45 that was one of the five half-sib families combined to produce C80. The testcross produced from family R280-45 had the best overall performance for all traits at all locations. The mother roots selected for resistance to rhizomania and *Erwinia* and reselected for sugar concentration and yield were increased in isolation. C80-45 has been tested as breeding lines R480-45 and R280-45.

C82 is a selection and recombination of lines similar to C76-43 and C76-89. Following three backcrosses of rhizomania resistance to C31/6, the third cycle synthetic selected for resistance to rhizomania was crossed to C31-43 and C31-89 to produce breeding lines R76-43 and R76-89. Plants from within each of these breeding lines were selected for resistance to rhizomania and the lines increased separately. These two cycle-one synthetics were grown in an overwintered nursery to evaluate and select for nonbolting tendency. Twelve month old, nonbolted mother roots were selected from each line and then reselected based upon sucrose concentration. Mother roots from both lines were then recombined in an isolated seed increase to produce C82. C82 will be evaluated as breeding line R482NB. It should be similar in performance to breeding lines tested as R384 and R282.

SOURCES OF RESISTANCE TO RHIZOMANIA LINES C79-1 through C79-11 – These near isogenic lines of C37 were released in 1994. Each has resistance to rhizomania, caused by beet necrotic yellow vein virus. Each line in the C79 series involved a different initial source that was known or had been identified as having resistance to rhizomania. C37 was chosen as the recurrent parent because of its adaptation to the western USA. Extractions from breeding lines similar to C37 have been widely used as parental lines in both USDA and proprietary commercial hybrids. C37 is a closely bred, self-sterile, multigerm line that is homozygous for green hypocotyl color and has low to intermediate vigor. It has good resistance to curly top virus, Erwinia root rot, caused by *Erwinia carotovora* (Jones) Bergey et al. subsp. *betavasculorum* Thomsen et al., and bolting. C37 is tolerant to virus yellows, caused by beet yellows and beet western yellows viruses. It is uniformly susceptible to rhizomania. Except for resistance to rhizomania, C79 near-isolines should be similar to C37.

Lines in the C79 series will segregate for resistance to rhizomania. Because rhizomania resistance could be tracked through the backcrossing procedure, it is thought that resistance is dominant and usually monogenic. If this is so and no escapes were selected in the final (1993) cycle of selection, then the gene frequency for resistance in these lines will be about 0.5 and 75 percent of the individual plants will be resistant. Because of the number of backcrosses and lack of recombination between cycles, it is anticipated that minor and modifying genes that may have occurred in the sources were mostly deleted. In general, it was observed that with each backcross to C37 line vigor, and to some degree resistance to rhizomania, appeared to become diminished based upon field trial results.

For most backcrosses, rhizomania susceptible, green hypocotyl plants of C37 were used as the female parent. Crosses were made under paper bags as pair plant crosses in the greenhouse. Seed produced on C37 was harvested separately and composited. Usually 16 to 24 crosses were made per source per backcross. F_1's were identified by either or both hypocotyl color and resistance to rhizomania. Selections for resistance were made in 4 month old plants grown in uniformly BNYVV infested field plots. Plots were usually sown in early August after seed had been produced and processed in the early summer. Resistant plants were selected in the field in early December based upon absence of root symptoms, root size and shape, and freedom from bolting.

The attached table lists the number of crosses and backcrosses to C37 and other sugarbeet lines. It also briefly describes the sources of resistance to rhizomania. These sources vary from sugarbeet, Swiss chard, weed beet, to *Beta maritima*. This series of lines is being released as potentially new sources of resistance to rhizomania. The allelism or relationship among these sources has not been determined. These releases at this time also will allow other laboratories to do additional research on this material and to map resistance factors with RFLP or RAPD markers.

Sugarbeet germplasm releases C79-1 through C79-11
that segregate for resistance to rhizomania

Release No.	1994 Seed No.[1]	Tested as Line, F_1 No.[2]	Crosses to C37[3]	Crosses to SB[4]	Source of Resist. Line	aka
C79-1	R479	R79, 204	4	SB	Holly	Rz
C79-2	R424	R24, 250	4	4	WB41	C48
C79-3	R425	R25, 251	4	4	WB42	C48
C79-4	R428	R28, 202	6	6	PI206407	C28
C79-5	R432	R32, 201	3	3	It. weed beet	R04
C79-6	R434	R34, 245	2	SB	It. acc.	R05
C79-7[6]	R435	R35, 242	2	SB	Rima	SES
C79-8	R436	R36, 243	2	3	*B. maritima*	C50
C79-9	R437	R37, 247	2	5	WB 151	W3
C79-10	R441	R41, 248	1	4	WB 169	W1
C79-11	R442	R42, 249	1	4	WB 258	W2

[1]Seed lots produced and distributed in 1994. All of these seed lots represent the F_2 generation.

[2]Basic line numbers in Salinas program. Earlier versions of released seed tested in which year of seed production was inserted between R and two digit line number (e.g., R379 =

version of R79-1 produced in 1993) or before the three digit F_1 number and sometimes with cycle of selection as a suffix (e.g., R328R2 = version of C79-4 produced in 1993 following second cycle of selection for resistance to rhizomania).

[3]Number of crosses to C37. Except for R79-7 final cross or backcross was always to C37.

[4]Total number of crosses and backcrosses to sugarbeet (SB). SB means source was a sugarbeet line.

[5]Line or source in which resistance originated. aka = also known as; designation that also has been used to identify the source of resistance. Rz is from a Holly hybrid. WB 41, WB 42, and WB 151 are *B. maritima* accessions from Denmark probably collected by Viggo Lund about 1950. WB 169 is *B. m.* accession from Italy collected by Dr. G. Coons in 1971. WB 258 is *B. m.* accession from Italy collected by Dr. De Biaggi in 1979. C50 is composite cross of about 60 *B. m.* accessions (Salinas collection) onto sugarbeet; also known as R22. R04 is an annual, weedy beet accession from Italy provided by E. Biancardi. R05 is a sugarbeet accession from Italy. P.I. 206407 is listed as a sugarbeet accession from Turkey but the only resistant plant had Swiss chard traits. Lines previously released as C28, C48, and C50 were versions with fewer backcrosses to C37 or sugarbeet.

[6]Rima and F_1 were used as females; therefore, R79-7 has a sterile cytoplasm (CMS) and individual plants range from fully male sterile to nearly fully fertile. Partially restored pollen fertile plants should be used as male to purge CMS.

NEMATODE RESISTANT POPULATIONS C608 and C609 - These breeding lines were released in 1994. C608 and C609 are multigerm, self-fertile (S^f) populations that segregate for hypocotyl color, genetic male sterility, resistance to rhizomania (*Rz*), caused by beet necrotic yellow vein virus, and resistance to cyst nematode, *Heterodera schachtii* Schm. The line B883 from the Netherlands was the source of nematode resistance. B883 was derived from an alien addition line with *Beta procumbens* chromosome-1 developed at Salinas by Dr. H. Savitsky. These populations are being released as a combined source of nematode and rhizomania resistance in a background with adaptation and disease resistance needed for much of the western USA. Information is not yet available on the performance of these lines or their hybrids or on the transmission rate of nematode resistance.

C608 and C609 are the equivalent of the BC_3 F_2 generation. BC_3 F_1 plants were selected for resistance to both cyst nematode and rhizomania from populations growing in dually infested field plots. In addition, the aberrant growth traits linked to cyst nematode resistance were used as an aide in identifying nematode resistant genotypes. Selected plants within each line were increased in mass under isolated conditions. The BC_3 F_2 seed will

be from a mixture of selfing and sibbing (primarily through the genetic male-sterile segregates). The frequency of *Rz* should be about 0.75. The frequency of the resistance factor for cyst nematode resistance is undetermined but because of the low transmission rate through gametes, particularly through pollen, is probably considerable less than 0.5, the theoretical frequency for a single, dominant allele. None-the-less, it can be expected that heterozygous resistant plants can be easily found but that homozygous resistant plants will occur at a low frequency.

C608 and C609 should be nearly identical. The recurrent parent for all backcrosses in their development was similar to C918 population. C608 was developed through homozygous, nematode resistant line C603. C609 was developed from a cross between C46 and B883. Except for the genes linked to the cyst nematode resistance factor, these populations should retain only about 4 percent of the B883 parentage. They should be useful as the source for developing genetically stable, homozygous nematode and rhizomania resistant breeding lines, for intrapopulation improvement, and/or as the source for making additional backcrosses to elite parental lines. Because these self-fertile lines segregate for genetic male sterility, male-sterile segregates could be used as the female to achieve a relative high transmission rate for nematode resistance.

VIRUS YELLOWS RESISTANCE – Breeding for resistance to virus yellows (BYV/BWYV) at Salinas has been a long term project. One of the base populations (C01) developed at Salinas starting in 1965 has been important as a source of commercial pollinators and as one of the best sources of VY resistance (probably resistance to BWYV and tolerance to BYV). Advances within this base line have been periodically released as C01, C31, C31/6, C31-43, and C31-89 (see chart below). The most recent development that may merit release is a selected full-sib family line called R76-89-18 that combines improved VY resistance with resistance to rhizomania and other diseases.

DEVELOPMENT OF LINE C76-89-18

1965	C01	Population generated
1977	C31	Cycle 4 from C01 for VYR, ...
1986	C31/6	Cycle 6 from C31 for VYR, ...
1991	C31-43 C31-89	HS progeny selections from C31/6 for VYR & GCA
1995	C76-89-18	Conversion to *Rz* & FS progeny selection for VYR, NB, ERR, GCA, ...

When compared to obsolete O.P. variety US75, C76-89-18 has improved sugar yield, root yield, and % sugar. In comparison to C31/6, it also appears to have an additional increment of VY resistance.

PERFORMANCE OF C76-89-18 AT SALINAS

Variety		Sugar Yield (lbs/a)		Relative Yield
		Non-Inoc	BYV/BWYV	
				%
US 75	Susc.line	12,100	5,700	47
C31/6		15,400	9,400	61
C76-89-18		14,300	10,100	71
R322Y3	SB x Bm	15,900	10,500	66
LSD (.05)		1,300	800	

Non-Inoc: plt'd. Feb. 14, 1994; harv. Sept. 27
BYV/BWYV: plt'd. Mar. 14, 1994; harv. Oct. 5

This improved VY resistance is also evidenced in the performance of a testcross hybrid.

HYBRID PERFORMANCE OF C76-89-18

Variety		Sugar Yield (lbs/a)		Relative Yield
		Non-Inoc	BYV/BWYV	
				%
6770	Susc.hybrid	15,400	7,600	49
CMS x C31/6 Rz		14,600	9,400	64
CMS x C76-89-18		14,300	10,000	70
LSD (.05)		900	800	

Non-Inoc: plt'd. Feb. 15, 1994; harv. Sept. 15
BYV/BWYV: plt'd. Mar. 14, 1994; harv. Sept. 29

R76-19-18 represents the most advanced breeding line in the VY resistance breeding program. In searching for additional or stronger sources of VY resistance, the line released as C50 [C50 = F_3 (sugarbeet x B.maritima)] has undergone three cycles of recurrent phenotypic selection for VY resistance. Despite being half B.maritima, 1994 test results suggest that this line may be a new source of VY resistance and factors for productivity.

Under BYV/BWYV inoculated conditions, it had higher yield than either C31/6 or C76-89-18 (see chart above). Crosses and reselections to sugarbeet base lines are now being made to determine if this apparent variability for VY resistance can be transferred to sugarbeet.

PERFORMANCE OF SOURCES OF RESISTANCE IN C37 BACKGROUND - As noted in an earlier statement on releases C79-1 through C79-11, as sources of resistance to rhizomania have been found, they have been backcrossed into C37 to create near-isolines. The description of the sources of resistance were given. The following chart gives the relative sugar yield of some of these near-isolines, with different sources of resistance under different disease severities.

RESISTANCE TO RHIZOMANIA IN C37 BACKGROUND

		Relative Sugar Yield			
		None	Mod	Severe	Severe
C37	Susc. line	100	100	100	100
R379	C37 Rz	102	107		152
R336	*B. maritima*	116	141	174	256
R328	PI 206407	104	126	154	143
R332	Ital. Weed B.	109	126	151	152
R334	Ital. Sugarb.	114	126	134	185
R337	WB 151	110	138	134	170
R338-4	WB 41 & 42		143		213

As noted in the chart above, under nondiseased conditions, the C37 near-isolines are not much different than C37 or C37Rz. Most of the differences are probably due to increased genetic variability coming from the source of resistance and not yet backcrossed out. With increasing severity, the near-isolines diverge from C37. Of interest is to note that most sources of resistance appear to give better protection (higher yields under diseased conditions) than the iso-line with the Holly gene Rz. In part, this also may be due to modifying factors from the resistance source that are not present in association with the Rz factor.

RESISTANCE TO RHIZOMANIA IN C37 BACKGROUND

		Relative Sugar Yield			
		None	Mod	Severe	Severe
C37	Susc.line	100	100	100	100
R379	C37 Rz	102	107		152
R322R4	SB x *B.m.*	106	143	217	317
R336	C37 x R22R4	116	141	174	256

One of the sources of resistance is line R22 [R22 = C50 = F_3 (sugarbeet x B.maritima collection)]. When R322R4 is compared to C37 and C37Rz under the most severe conditions, it had more than 3-fold increase in sugar yield. However, after a cross to C37, resistance was not as good for the reselected F_2 line R336. This suggests that either modifying factors are involved and were diluted and/or that the major gene frequency was decreased and conditioned a lower level of resistance.

PERFORMANCE OF RHIZOMANIA RESISTANT HYBRIDS - In 1994, a set of hybrids and lines were evaluated at Salinas under different rhizomania infested conditions. conditions ranged from none to severe infestation. the complete results of these trials are presented elsewhere in this report and are briefly summarized here. In this summary the sugar yield performance of the six IIRB entries is compared to a resistant and susceptible USDA hybrid check and to the half B.maritima line R322R4. R322R4 had undergone four cycles of the recurrent phenotypic selection for resistance to rhizomania.

PERFORMANCE OF RHIZOMANIA RESISTANT VARIETIES

Variety		Sugar Yield (lbs/a)		
		None	Mod.	Severe
US H11	Susc. ck.	9,900	6,000	3,700
R78H52	USDA	10,600	9,400	7,600
Accord	Hilleshog	10,600	6,100	3,600
Monodoro	Hilleshog	10,300	8,300	5,900
Rizor	SES	10,100	9,000	7,400
Stratos	Strube	9,900	9,300	6,100
Roxane	Desprez	10,100	7,400	4,100
C48	KWS	11,400	8,900	7,200
R322R4	SB x *B.m.*	9,400	8,200	9,500
LSD (.05)		600	600	1,000

Planted late April 1994. Harvested Oct. 1994.

By-in-large big differences did not occur within this set of varieties when tested under nondiseased conditions. Much greater separation started occurring under moderate rhizomania infestation. With severe infestation, two-fold differences occurred within the hybrids.

PERFORMANCE OF RHIZOMANIA RESISTANT VARIETIES

| Variety | | Rel.* Sugar Yield (lbs/a) | | |
		None	Mod.	Severe
US H11	Susc. ck.	9,900	61	37
R78H52	USDA	10,600	89	72
Accord	Hilleshog	10,600	58	34
Monodoro	Hilleshog	10,300	81	57
Rizor	SES	10,100	89	73
Stratos	Strube	9,900	94	62
Roxane	Desprez	10,100	73	41
C48	KWS	11,400	78	63
R322R4	SB x *B.m.*	9,400	87	101
LSD (.05)		600		

Planted late April 1994. Harvested Oct. 1994.
*Relative to same variety in non-diseased test.

Although these tests were grown separately, they provided an opportunity to estimate relative losses across varieties. Under moderate rhizomania conditions, it is suggested that about 40% loss occurred for the susceptible checks and a 10-20% loss within the partially resistant entries. Under severe conditions, losses to the susceptible checks were greater than 60% and to the partially resistant hybrids 30-40%. Particularly under the severe conditions, other soil-borne problems, such as cyst nematode, may have contributed to these losses. Probably the most striking observation across these tests is the relative performance of R322R4. As observed in 1993 and reported in last year's report, resistance to rhizomania and possibly other soil-borne problems is much stronger in this line than in any of the tested hybrids.

RESISTANCE TO CYST NEMATODE - Progress in resistance breeding for combined resistance to sugarbeet cyst nematode (SBCN) and rhizomania (Rzm) was reported in the 1993 Sugarbeet Research Report. Two persistent problems with SBCN resistant breeding lines are the low transmission rate due to meiotic disturbances and the apparent linkage or association to low sucrose content. Presented below is a progress report on the SBCN breeding program as recently presented at the 28th Meeting of ASSBT.

DEVELOPMENT OF BEET CYST NEMATODE RESISTANCE

1956	Sugarbeet x *Beta procumbens*, Savitsky
1971	2N + 1 NR line released, Savitsky
1987	B883 2N homozygous NR line, the Netherlands, Heijbroek et al.
1988	CTR x B883, Salinas
1992	C603,C604 homozygous NR lines, Salinas
1994	BC_4F_1 heterozygous NR, rhizomania resistant backcross lines, 97% CTR germplasm

As the charts below show, repeated backcrossing in part corrects the problem with low sugar content. As backcrosses are made and the non-SBCN resistance contribution from B883 is decreased, there is an increase in % sucrose. For root yield, the association to SBCN resistance does not appear to be a concern.

PERFORMANCE OF SBCN RESISTANCE UNDER RHIZOMANIA/SBCN CONDITIONS

Variety	Description	Resistance RZM	SBCN	% B883	Relative % S
US H11		S	S		100
R378H52	CMS x C78	R	S		113
N303H52	CMS x C603	S	R	25	88
N244	BC_1F_2	R	R	25	95
N354	BC_2F_2	R	R	12	108

Mean of 4 tests with different levels of RZM/BCN. S = susceptible; R = resistant or segregating for resistance.

PERFORMANCE OF SBCN RESISTANCE UNDER
RHIZOMANIA SBCN CONDITIONS

Variety	Description	Resistance RZM	SBCN	% B883	Relative Root Yield
US H11		S	S		100
R378H52	CMS x C78	R	S		158
N303H52	CMS x C603	S	R	25	135
N244	BC_1F_2	R	R	25	136
N354	BC_2F_2	R	R	12	145

Mean of 4 tests with different levels of
RZM/SBCN. S = susceptible; R = resistant
or segregating for resistance.

The three charts below show that as the proportion of B883 is
decreased in a backcrossing series, the SBCN susceptible portion
of the backcross lines approaches the sugar concentration of the
recurrent parent (popn-915) as expected. However, the SBCN
resistant portion of these same backcross lines continues to show
a markedly lower sugar level. Based upon these paired contrasts,
breeding material that is differentiated only by the nematode
resistance factor (terminal translocation) and the factors
closely linked to it, there appears to remain a concern of
eventually how nematode resistant commerical hybrids will perform
for sucrose content.

PERFORMANCE OF NR vs NS PLANTS WITHIN
AND ACROSS BREEDING LINES

Breeding Line	Resistance RZM	SBCN	% B883	% Sugar NR	NS
US H11	S	S			14.8
popn-915	R	S			17.2
B883	S	R	100	8.0	
CMS x B883	S	R	50	10.5	
C603	S	R	50	11.0	
CMS x C603	S	R	25	13.5	
Rz x C603	R	R	25	15.7	

Test 3694: Severe rhizomania, moderate SBCN.
Pltd. 4/94; Harvd. 12/94. S = susceptible;
R = resistant or segregating for resistance.

PERFORMANCE OF NR vs NS PLANTS WITHIN AND ACROSS BREEDING LINES

Breeding Line	Resistance RZM	SBCN	% B883	% Sugar NR	NS
US H11	S	S			14.8
popn-915	R	S			17.2
B883	S	R	100	8.0	
C603	S	R	50	11.0	
N244(BC$_1$F$_3$)	R	R	25	15.8	15.4
N354(BC$_2$F$_2$)	R	R	13	15.8	16.2
BC$_1$S$_3$	R	R	25	14.7	15.6
BC$_2$S$_1$	R	R	13	14.9	16.2
BC$_3$F$_1$	R	R	6	15.5	16.8

Test 3694: Severe rhizomania, moderate SBCN. Pltd. 4/94; Harvd. 12/94. S = susceptible; R = resistant or segregating for resistance.

PERFORMANCE OF NR vs NS PLANTS WITHIN AND ACROSS BREEDING LINES

Breeding Line	Resistance RZM	SBCN	% B883	% Sugar NR	NS
US H11	S	S			11.0
popn-915	R	S			13.0
C603	S	R	50	6.4	
CMS x C603	S	R	25	8.7	
Rz x C603	R	R	25	10.7	
BC$_1$S$_3$	R	R	25	9.8	10.6
BC$_2$S$_1$	R	R	13	10.7	12.0
BC$_3$F$_1$	R	R	6	10.6	12.7

Test 5294: Severe rhizomania, moderate SBCN. Pltd. 5/94; Harvd. 12/94. S = susceptible; R = resistant or segregating for resistance.

In 1994, estimates were made of the transmission rates of several backcross families through both the female and male gametes. The results of reciprocal crosses between resistant plants and the susceptible recurrent parents and through the F_1 to the F_2 are given below. As observed many times previously by other investigators, transmission rates are lower than expected, are usually lower through the male than the female gametes, and differ from family to family.

TRANSMISSION RATE FROM SBCN RESISTANT HETEROZYGOTES

Family	Generation	Cross	Observed NR	NS	Transmission Exp. %	Obs. %
N357	BC_3F_1	R x S	42	119	50	26
N358	BC_3F_1	S x R	23	116	50	16
N354	BC_2F_2	R x R	65	104	75	38
N359	BC_3F_1	R x S	4	32	50	11
N360	BC_3F_1	S x R	2	73	50	3
N355	BC_2F_2	R x R	10	124	75	7
N361	BC_3F_1	R x S	8	8	50	50
N362	BC_3F_1	S x R	10	65	50	13
N350	BC_2F_2	R x R	7	12	75	37

Scored under SBCN/RZM field conditions, 1994.

In determining the transmission rate and designing a SBCN resistance breeding program for the future the following assumptions were made.

TRANSMISSION RATE FROM SBCN RESISTANT HETEROZYGOTES -- ASSUMPTIONS

- SBCN resistance is inherited like a single, dominant allele but produces disturbed ratios due to meiotic irregularities.

- SBCN resistance and crown galling are tightly linked and galling can be used as a marker in the absence of reliable infestations of nematode.

- Mistakes or misclassifications were not made during crossing, scoring, and selecting individual plants.

After producing backcross families that are nearly equivalent to advanced, disease resistant, high performing lines, the next challenge is to produce easily and in relatively high numbers, homozygous, true-breeding, SBCN resistant (NR) lines. This has been difficult because of the low transmission rate of NR. Once large numbers of homozygous NR lins are identified, they can be pooled into populations for further improvement and/or individually entered into progeny and combining ability tests to identify potentially useful parental lines. Once a few homozygous NR lines are identified, these could be used in a

modified backcrossing program to greatly increase the recovery
rate of new homzygous NR lines as shown by the following chart.

USE OF HOMOZYGOUS NR POLLINATORS
DURING BACKCROSSING TO INCREASE RECOVERY
OF NEW HOMOZYGOUS NR LINES

```
F₁ Nn x NN
     ↓
BCₙF₁
    NN -- selfed --> BCₙS₁  NN
    Nn -- selfed --> BCₙS₁  NN:Nn:nn
```

The following chart shows the present position of the
conventional and modified backcrossing program at Salinas. Onto
BC₃F₁ plants selected for nematode (Nn) and rhizomania resistance
and represented as being 94% curly top resistant (CTR) germplasm,
homozygous resistant (NN) line C604 was used as the pollinator in
1994. The resultant seed and plants should segregate NN:Nn and
in a progeny test the relative high number of NN lines could be
identified. If transmission rate through the homozygous (NN)
male is 100% and through the heterozygous female 20%, then a
theoretical recovery of 20% homozygous (NN) plants or S₁ lines
could be identified and selected.

USE OF HOMOZYGOUS NR POLLINATORS
DURING BACKCROSSING TO INCREASE RECOVERY
OF NEW HOMOZYGOUS NR LINES

```
BC₃F₁ Nn (94% CTR) x C604 NN (50% CTR)
        ↓
BCₙF₁ (72% CTR)
    NN -- selfed --> BCₙS₁  NN        selected
    Nn -- selfed --> BCₙS₁  N_:nn     discarded
```

In the 1995 greenhouse crossing program, the conventional BC₄F₁
(97% CTR) Nn plants will be crossed as females to the NN:Nn (72%
CTR) plants generated and selected in 1994. From the resultant
breeding material (84% CTR), we will attempt to identify the NN
lines in progeny tests. These should then be sufficiently like
Salinas multiple disease resistant material to be entered into a
more conventional population improvement and breeding program.
If it is assumed that for this program, material is used that has
a 20% transmission rate through the female and a 10% rate through
the male, then about 4% of the 84% CTR plants will be NN. After

discarding the nn plants in a mother root selection program, about 10% of the remaining mother roots may be NN. This will be a high enough frequency to accomodate the next phase of the NR breeding program.

USE OF HOMOZYGOUS NR POLLINATORS
DURING BACKCROSSING TO INCREASE RECOVERY
OF NEW HOMOZYGOUS NR LINES

BC_4F_1 Nn (97% CTR) x BC_nF_1 NN:Nn (72% CTR)

   ↓

$\underline{BC_nF_1 \text{ (84% CTR)}}$

  NN -- selfed --> BC_nS_1 NN   selected

  Nn -- selfed --> BC_nS_1 N_:nn discarded

  NN -- selfed --> BC_nS_1 NN   selected

  Nn -- selfed --> BC_nS_1 N_:nn discarded

  nn   discarded

TEST 1394. EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1994

48 entries x 8 reps., RCB(equalized); 3 subtests, 16 x 8, RCB (equalized)   Planted: February 14, 1994
1-row plots, 21 ft. long   Harvested: September 26-27, 1994

Variety[1]	Description	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew %	Bolting %	RJAP %
Test 1394-1 (16 varieties x 8 reps, RCB)									
Rhizoguard	rec'd 9/21/93	15793	48.60	16.24	0.0	144	8.3	0.9	84.5
Rizor	RZ3/1022	16580	46.75	17.71	0.0	149	7.4	0.0	83.7
F86-31/6	Inc. C31/6 (L86263)	15382	46.38	16.59	0.0	134	5.8	0.0	83.6
R376	RZM R276	15546	49.70	15.63	0.0	148	7.3	0.9	83.9
R376Y	RZM R276Y	16431	52.25	15.71	0.0	140	6.4	0.0	84.5
R384	Inc. R176-43-#,-89-#	15926	47.76	16.66	0.0	140	5.9	0.0	83.7
R381-43	RZM R281-43	16972	52.73	16.11	0.0	140	5.8	3.4	85.2
R381-89	RZM R281-89	16934	51.90	16.33	0.0	137	6.0	0.0	83.5
R376-43	RZM R276-43	16545	50.83	16.26	0.0	137	5.8	0.0	83.8
R376-43-#(C)	Inc. R176-43-#(C76-43)	16637	51.32	16.21	0.4	134	4.9	0.0	85.2
R376-43-14	Inc. R176-43-14	15949	49.95	15.99	0.0	139	6.4	0.0	85.0
R376-43-15	Inc. R176-43-15	14945	45.35	16.49	0.0	136	2.6	0.0	85.3
R376-89	RZM R276-89	16650	50.27	16.54	0.0	143	6.4	0.0	83.8
R376-89-#(C)	Inc. R176-89-#(C76-89)	15645	47.47	16.48	0.0	143	6.7	0.0	85.0
R376-89-5	Inc. R176-89-5	14110	41.03	17.20	0.0	136	6.1	0.0	83.1
R376-89-18	Inc. R176-89-18	14324	43.46	16.50	0.4	132	6.4	0.0	83.9
Mean		15898.2	48.48	16.42	0.1	139.6	6.1	0.3	84.2
LSD (.05)		1235.4	3.52	0.45	0.4	9.4	0.8	1.0	1.4
C.V. (%)		7.9	7.34	2.75	807.6	6.8	13.6	310.2	1.7
F value		4.0**	0.56**	10.27**	0.9NS	2.1*	17.3**	6.1**	2.0*

TEST 1394. EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1994

48 entries x 8 reps., RCB (equalized). ANOVA to compare means across sets of entries.

		Sugar Lbs	Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew %	Bolting %	RJAP %
Mean		15770.4	48.61	16.24	0.1	140.7	6.5	0.4	84.2
LSD (.05)		1311.0	3.92	0.49	0.5	9.1	0.8	1.3	1.6
C.V. (%)		8.4	8.19	3.09	588.7	6.6	12.4	333.2	2.0
F value		5.1**	5.43**	16.79**	1.8**	3.2**	24.6**	9.9**	2.3**

See Test 1694 for corresponding entries under virus yellows conditions and Test 4594 for performance under rhizomania conditions.

[1]R376, R376-#'s, R381-#'s = Rz in C31/6 background; R376-#-#'s = increases of selected full-sib families.

TEST 1394. EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1994

(cont.)

Variety²	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew %	Bolting %	RJAP %
Test 1394-2 (16 varieties x 8 reps, RCB)									
4454	Commercial check	17878	54.35	16.50	0.0	154	4.8	0.0	85.7
KWS 6770	High % S check	17377	46.55	18.64	0.0	151	6.5	0.8	85.6
Y347	YR-ER-PM Y147 (C47)	15575	46.60	16.73	0.0	140	5.9	0.0	84.9
268	Inc. 768 (US 75)	12145	39.71	15.32	1.2	146	8.0	0.0	82.3
U86-46/2	Inc. C46/2 (86342)	15246	46.24	16.49	0.0	142	5.4	0.0	83.6
R378	RZM R278, R278Y	15235	46.40	16.39	0.0	135	5.5	0.0	83.8
R378	RZM R278	15881	47.40	16.75	0.0	143	5.3	0.0	85.1
R378Y	RZM R278Y	15924	48.05	16.59	0.0	148	5.9	0.0	84.4
R380	RZM R280, R280Y	15517	47.80	16.26	0.0	133	6.4	0.0	83.8
R380	RZM R280	15747	47.59	16.56	0.0	139	7.6	0.0	84.6
R380Y	RZM R280Y	16366	50.11	16.33	0.0	143	6.7	0.0	84.3
R370	RZM R270Y	17010	52.51	16.20	0.5	143	6.3	0.0	85.4
Y339	YR-ER-PMR Y139 (C39)	15788	45.28	17.41	0.0	136	2.6	0.0	84.6
R139C7	RZM R039C6 (C39R)	17291	53.04	16.31	0.0	143	3.1	1.2	85.4
R322R4	RZM R122R3 (GSY)	14659	48.24	15.20	0.4	148	8.0	9.3	82.0
R322Y3 (%)	YR-ER-PMR R122Y2 (%S)	15926	47.75	16.69	0.0	152	6.3	0.8	81.8
Mean		15847.8	47.98	16.52	0.1	143.5	5.9	0.8	84.2
LSD (.05)		1312.5	3.96	0.46	0.6	8.0	0.9	1.9	1.4
C.V. (%)		8.4	8.33	2.82	453.6	5.7	14.6	257.7	1.7
F value		8.0**	5.91**	21.73**	2.5**	4.4**	25.1**	11.2**	5.9**

²R378 = Rz in C46/2. R380 = Rz in C54. R370 = Composite of Rz lines. R322R4 = 4th cycle selection for rhizomania resistance from C50, (C54 x B.maritima). R322Y3% = 3rd cycle selection for virus yellows resistance from C50.

(cont.)

Variety[3]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/100' No.	Powdery Mildew %	Bolting %	RJAP %
Test 1394-3 (16 varieties x 8 reps, RCB)									
US H11	rec'd 1/10/94	15412	47.85	16.11	0.0	152	8.8	0.4	84.2
3911	YR-ER-PMR popn-911 (A,aa)	15946	48.47	16.44	0.0	141	5.1	0.0	85.7
3915	2915,...,2911Yaa x A	16824	52.92	15.90	0.0	131	6.8	0.0	84.3
3918	1913-#,1915-#aa x A (C918)	16715	51.61	16.20	0.0	132	6.8	0.0	83.2
3918-#(C)	Inc. 1913-#,1915-# (A,aa)	14709	46.30	15.89	0.0	131	7.2	0.0	84.2
3916	RZM 2916 (A,aa)	15945	51.46	15.49	0.0	145	7.8	0.0	83.6
3910	RZM 2210-#(C) (A,aa)	15088	47.74	15.80	0.0	148	7.4	0.0	85.1
N303H15	2915aa x C03,C03-1	15932	56.03	14.24	0.0	137	8.2	0.4	84.5
N354	NR-RZM N254-#-#(C) (A,aa)	14274	47.97	14.88	0.9	135	8.3	0.0	84.1
R309,10	RZM R209-#(C),R210-#(C)	16940	53.59	15.80	0.0	140	7.0	0.4	84.3
Z325	RZM Z120,...,Z124 (A,aa)	16069	46.72	17.20	0.0	140	7.1	0.0	85.1
Z330	RZM Z230 (A,aa)	16450	50.67	16.24	0.0	141	7.8	0.0	83.7
3859m	2859mmaa x A (C859)	13712	43.65	15.72	0.0	139	8.4	0.0	84.4
3867m	2867mmaa x A	14540	48.78	14.91	0.0	140	8.0	0.0	84.6
3890	0790mmaa x A (C890)	15587	49.06	15.89	0.0	134	7.8	0.0	83.8
3894	RZM MR Comp. mmaa x A	14899	46.95	15.88	0.4	134	7.9	0.0	83.4
Mean		15565.2	49.36	15.79	0.1	138.9	7.5	0.1	84.3
LSD (.05)		1307.5	3.90	0.55	0.5	8.2	0.6	0.5	2.0
C.V. (%)		8.5	7.97	6.33	611.6	5.9	7.7	648.2	2.4
F value		4.2**	5.13**	12.37**	1.9*	4.2**	18.0**	0.9NS	0.9NS

[3]3910, 3911, 3915, 3916, 3918 = S^f,MM,A:aa,Rz populations. N303H15 & N354 = lines with combined cyst nematode and rhizomania resistance. R309 & R310 = line with combined resistance to rhizomania and cercospora leaf spot. Z325 & Z330 = lines with 50 &25% germplasm from high sugar Polish accessions. 3859, 3867, 3890, and 3894 = populations that segregate for monogerm and resistance to rhizomania.

TEST 4594-1,2,3,4.   RHIZOMANIA EVALUATION OF LINES, SALINAS, CA., 1994

64 entries x 8 reps., RCB (equalized)
1-row plots, 20 ft. long
4 subtests each with 16 entries x 8 reps, RCB (equalized)

Planted: May 10, 1994
Harvested: October 17-18, 1994

| Variety[1] | Description | Acre Yield | | Sucrose | Beets/ 100' | Powdery Mildew | Bolting | RJAP |
		Sugar Lbs	Beets Tons	%	No.	%	%	%
Test 4594-1.								
US H11	L113401	6445	23.26	13.84	190	6.7	0.0	85.5
Rhizoguard	Holly (9/21/93)	8232	28.54	14.43	174	6.2	0.0	83.3
Rizor	R23/1022 (1/21/93)	9309	28.49	16.34	177	6.0	0.0	81.1
R039C5	C39R, Inc. R939C5	8991	30.53	14.71	167	1.4	0.3	83.7
F86-31/6	Inc. C31/6, 86263	7093	23.80	14.88	161	3.0	0.0	84.2
R376	RZM R276	7615	26.76	14.25	159	4.4	0.0	83.5
R376Y	RZM R276Y	8670	29.30	14.79	165	4.1	0.0	84.9
R376-43	RZM R276-43	8267	28.39	14.57	162	3.2	0.0	82.9
R381-43	RZM R281-43	8799	30.03	14.66	173	2.8	0.0	83.2
R376-89	RZM R276-89	8930	29.74	15.01	171	3.3	0.0	83.4
R381-89	RZM R281-89	8696	29.54	14.73	162	3.1	0.0	82.2
R384	Inc. R176-43;-89-#	7033	24.05	14.61	164	3.2	0.0	84.4
U86-46/2	Inc. C46/2,86342	7212	24.47	14.69	149	2.8	0.0	83.0
R378	RZM R278	8571	27.93	15.34	158	2.2	0.0	83.0
R378Y	RZM R278Y	9001	30.08	14.96	158	2.3	0.0	81.9
R370	RZM R270Y	8608	29.87	14.41	169	3.6	0.0	82.6
Mean		8217.0	27.80	14.76	166.1	3.6	0.0	83.3
LSD (.05)		704.4	2.30	0.43	13.9	1.2	0.2	1.8
C.V. (%)		8.7	8.37	2.91	8.4	33.4	1116.2	2.2
F value		11.7**	9.37**	12.56**	3.7**	12.4**	1.0NS	3.1**

TEST 4594. RHIZOMANIA EVALUATION OF LINES, SALINAS, CA., 1994

64 entries x 8 reps, RCB (equalized); 1-row plots, 20 ft. long.   ANOVA to compare means across sets.

Mean		8161.6	27.99	14.58	173.6	4.5	0.3	82.7
LSD (.05)		749.6	2.37	0.49	13.0	1.0	1.3	2.2
C.V. (%)		9.3	8.61	3.39	0.6	22.2	425.9	2.6
F value		8.2**	9.22**	10.35**	4.6**	19.1**	10.9**	3.1**

See Test 1394 and 1694 for corresponding entries under nondiseased and virus yellows conditions.

[1] See Test 1394 for descriptions.

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TEST 4594-1,2,3,4. RHIZOMANIA EVALUATION OF LINES, SALINAS, CA., 1994

(cont.)

Variety[2]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Powdery Mildew %	Bolting %	RJAP %
Test 4594-2.								
US H11	L113401	6526	23.09	14.11	193	6.7	0.0	85.6
Y954	Inc. Y854 (C54)	7785	25.76	15.07	176	3.7	0.0	83.2
R380	RZM R280	8890	29.86	14.88	159	4.8	0.0	82.2
R380Y	RZM R280Y	9385	31.48	14.90	186	3.6	0.0	83.0
R722	Inc. F$_2$(Y54 x B.m.)(C50)	7274	25.73	14.11	184	5.0	3.2	82.0
R122R3	RZM R022R2, C50R3	8253	29.45	14.01	181	4.1	1.1	80.6
R222R4	RZM R122R3, C50R4	8388	30.24	13.88	182	4.7	0.0	77.8
R322R4	RZM R122R3 (GSY)	8323	28.98	14.36	182	4.9	0.6	79.8
R322R4%	RZM R122R3 (%S)	8222	28.37	14.49	194	4.1	0.3	80.5
R022Y	Inc. R922Y, C50Y1	7853	27.01	14.56	176	4.9	0.0	82.2
R122Y2	BYV R922Y, C50Y2	8481	28.83	14.71	186	3.5	0.0	82.1
R322Y3	YR-ER-PMR R122Y2 (GSY)	8003	26.99	14.82	181	3.5	0.0	80.4
R322Y3%	YR-ER-PMR R122Y2 (%S)	8068	26.15	15.45	184	3.7	0.0	82.3
R338H52	F92-790-15H39 x R38(C)	9030	31.02	14.56	178	5.4	0.0	82.9
N354	NR-RZM N254-#-#(C)	8098	28.98	14.00	183	5.6	0.0	83.7
N303H15	2915aa x C03,C03-1	8895	33.13	13.41	177	5.9	0.0	82.9
Mean		8217.2	28.44	14.46	181.4	4.6	0.3	81.9
LSD (.05)		774.3	2.35	0.57	9.9	0.9	1.5	2.8
C.V. (%)		9.5	8.34	4.00	5.5	19.7	464.6	3.5
F value		6.3**	9.25**	6.46**	4.9**	8.8**	2.4**	3.2**

[2]See Test 1394 for descriptions.

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TEST 4594-1,2,3,4.   RHIZOMANIA EVALUATION OF LINES, SALINAS, CA., 1994

(cont.)

Variety[3]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Powdery Mildew %	Bolting %	RJAP %
Test 4594-3.								
U86-37	Inc. C37, (86443)	5820	20.53	14.19	188	6.6	0.0	83.2
R379	RZM R279,R279Y,R279R2,(Rz)	6241	21.89	14.23	180	6.0	0.0	82.2
R336	RZM 2243-#(C),(R22)	8207	29.98	13.71	183	6.5	0.0	81.0
R332	RZM 2201-#(C),(R04)	7302	26.04	14.01	183	5.5	0.3	82.7
R332R2	RZM R232, (R04)	8183	29.87	13.70	176	5.8	1.1	83.5
R328	RZM 2202-#(C), (PI07)	7280	25.57	14.21	179	6.9	0.0	82.0
R328R2	RZM R228, (PI07)	7174	24.36	14.69	181	6.7	0.0	82.2
R334	RZM 2245-#(C), (R05)	7342	24.05	15.27	173	5.6	0.0	82.8
R337	RZM 2247-#(C), (WB151)	8035	26.57	15.13	177	5.5	0.0	83.0
R335	RZM 2242-#(C), (Rima)	8727	29.23	14.96	180	6.4	0.0	80.8
R338-4	R221 x R38(C), (WB41/42)	8274	27.89	14.82	182	6.9	0.0	83.0
R338-1,2,3	RZM R279R2,I,Y x R38(C)	7708	26.04	14.82	167	5.9	0.0	83.0
Y339	YR-ER-PMR Y139, C39	7707	24.68	15.60	169	1.1	0.0	83.0
R239C8	C8, RZM R139C7, C39R	8862	30.48	14.55	162	1.9	0.7	84.8
R347	YR-ER-PMR Y147, C47	8313	26.88	15.45	173	3.0	0.0	82.3
R247C8	C8, RZM R147C7, C47R	8616	29.96	14.36	183	5.8	0.0	84.0
Mean		7736.9	26.50	14.61	177.2	5.4	0.1	82.7
LSD (.05)		715.0	2.38	0.47	11.4	0.7	0.8	2.0
C.V. (%)		9.3	9.09	3.28	6.5	12.7	585.8	2.5
F value		11.2**	12.22**	11.99**	2.8**	53.9**	1.3NS	1.9*

[3]U86-37 = C37 = recurrent parent for rhizomania resistance program. R379 = C37Rz. R336, R332, R328, R334, R337, R335 = F_2BC_n C37 x source of resistance. Source of resistance is shown in parentheses. R332R2, R328R2 = F_3BC_n C37 x source. R338-1,-2,-3 = C37Rz x sources of resistance.

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TEST 4594-1,2,3,4. RHIZOMANIA EVALUATION OF LINES, SALINAS, CA., 1994

(cont.)

Variety[4]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Powdery Mildew %	Bolting %	RJAP %
Test 4594-4.								
5747	4747aa x A	8027	28.86	13.90	156	6.1	0.0	84.7
3910	RZM 2210-#(C) (A,aa)	8317	29.09	14.29	181	5.3	0.0	82.0
3911	YR-ER-PMR popn-(C) (A,aa)	8696	29.28	14.86	164	2.1	0.0	83.3
3915(Sp)	2911,...,2915aa x A	9260	31.24	14.80	165	4.0	0.0	82.1
9903	YR-ER-PMR 7903 (A,aa)	7834	26.83	14.59	179	4.3	0.0	84.8
3918-#(C)	Inc. 1913-#,1915-#(S$_1$)(A,aa)	7969	27.99	14.20	168	3.1	0.0	82.6
3918	1913-#,1915-#aa x A	8953	30.71	14.57	159	2.5	0.0	83.0
R329	RZM 2206-#(C),(A,aa),(PIO7)	8198	28.98	14.16	166	5.8	0.0	82.4
R329R2	RZM R229, (PIO7)	7965	28.49	13.98	170	6.6	0.0	81.3
R333	RZM 2205-#(C)(A,aa),(R04)	7667	28.35	13.54	183	5.0	11.9	83.6
Z325	RZM Z120,Z122,Z124 (A,aa)	8725	26.79	16.27	163	4.3	0.0	83.8
Z330	RZM Z230 (A,aa)	8924	30.08	14.82	178	4.9	0.0	81.3
R309	RZM R209-#(C) (A,aa)	9119	31.29	14.57	178	4.4	0.0	82.4
R310	RZM R210-#(C) (A,aa)	9020	31.62	14.27	165	2.9	0.0	83.1
3917	RZM 2917-#(C) (A,aa)	8399	28.46	14.75	173	2.4	0.4	83.5
3916	RZM 2916 (A,aa)	8534	29.66	14.39	170	4.5	0.0	83.4
Mean		8475.5	29.23	14.50	169.8	4.2	0.8	82.8
LSD (.05)		716.8	2.26	0.46	11.4	0.9	2.0	1.9
C.V. (%)		8.5	7.80	3.17	6.8	22.5	265.7	2.4
F value		3.8**	3.34**	13.69**	4.0**	16.2**	17.0**	2.3*

[4]Self-fertile,MM,A:aa populations. 5747 = S^f,MM,A:aa recurrent popn similar to C37. 9903 = S^f,MM,A:aa recurrent popn similar to C46. Z325 & Z330 = popns with 50 & 25% high sugar Polish germplasm. R309 & R310 = Rz combined with CLSR. 3917 = S^f,A:aa C39.

TEST 5794. RHIZOMANIA EVALUATION OF SELF-FERTILE POPULATIONS, SALINAS, CA., 1994

Planted: May 23, 1994
Harvested: December 1, 1994

16 entries x 8 replications, RCB (equalized)
1-row plots, 20 ft. long
2 subtests each: 8 x 8 , RCB (equalized)

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolting %	RJAP %
5794-1 MM popns							
5747	4747aa x A	3173	13.16	11.99	149	0.0	74.9
3915	2911,...,2915aa x A	4972	18.98	13.14	158	0.0	74.5
3918	1913-#,1915-#aa x A	4289	15.81	13.55	150	0.0	75.0
R329	RZM 2206-#(C),(A,aa)(PIO7)	4235	17.24	12.25	166	0.3	74.9
R333	RZM 2205-#(C),(A,aa)(RO4)	3604	16.71	10.73	173	7.1	77.3
Z330	RZM Z230(A,aa)	5199	20.01	13.01	184	0.0	75.3
R309	RZM R209-#(C)(A,aa)	5732	22.59	12.66	173	0.0	75.1
R310	RZM R210-#(C)(A,aa)	5651	22.23	12.65	184	0.0	75.5
Mean		4607.0	18.34	12.50	167.0	0.9	75.3
LSD (.05)		528.1	1.88	0.72	13.7	1.2	4.0
C.V. (%)		11.4	10.20	5.72	8.2	127.5	5.2
F value		25.4**	24.02**	22.34**	8.4**	35.5**	0.4NS
5794-2 mm popns[2]							
0790	8790-S$_1$(C)aa x A	2946	12.23	12.00	165	0.0	77.1
3859m	2859mmaa x A	4469	17.44	12.85	148	0.0	76.0
3865	Inc. 1865-#'s(A,aa)	3739	13.94	13.45	180	0.0	73.7
3867m	2867mmaa x A	4158	17.63	11.79	168	0.0	74.0
3890	0790mmaa x 2890	3681	14.99	12.25	142	0.0	76.7
3892	2890mmaa x A	4101	16.41	12.45	158	0.0	78.4
3893m	(C)mmaa x mm,O-T	4551	19.02	11.98	141	0.0	76.1
3894m	MR(C)mmaa x A	4785	19.18	12.52	162	0.0	74.2
Mean		4054.0	16.35	12.41	157.8	0.0	75.8
LSD (.05)		588.6	1.98	0.76	16.8		2.8
C.V. (%)		14.5	12.05	6.11	10.6		3.7
F value		8.1**	12.54**	4.10**	5.3**		2.9*

TEST 5794. RHIZOMANIA EVALUATION OF SELF-FERTILE POPULATIONS, SALINAS, CA., 1994

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/ 100' | Bolting | RJAP |
		Sugar Lbs	Beets Tons	%	No.	%	%
Mean		4330.5	17.35	12.45	162.4	0.5	75.5
LSD (.05)		614.1	2.15	0.80	18.5	0.9	3.4
C.V. (%)		14.3	12.51	6.47	11.5	193.2	4.6
F value		13.6**	14.94**	6.08**	4.6**	31.1**	1.2NS

TEST 5794. RHIZOMANIA EVALUATION OF SELF-FERTILE POPULATIONS, SALINAS, CA., 1994

16 entries x 8 replications, RCB (equalized); 2 subtests each: 8 x 8 , RCB (equalized)
1-row plots, 20 ft. long. ANOVA to compare means across sets.

See Test 1394, 1694, and 4594 for the performance of these lines under nondiseased, virus yellows, and less severe rhizomania. Tests in the 5094 series were planted in late May in a field with severe rhizomania at the USDA Research Station, rather than at Spence Field. Test had light infection with cercospora leaf spot.

[1]5747 = $S^f,MM,A:aa$ rhizomania susceptible recurrent parent similar to C37.   3918 = C918 = $S^f,MM,A:aa$ population segregating for Rz.   R329 & R333 = F_2BC_n lines with PI206407 or R04 (Italian weed beet) sources of resistance. Z330 = $S^f,MM,A:aa,Rz$ line with 25% high sugar Polish germplasm.   R309 & R310 are lines that combine resistance to rhizomania and CLS.

[2]0790 = C790 = $S^f,MM,A:aa$ rhizomania susceptible recurrent population (Source of C790-15 et al.).   3890 = 0790 with low frequency of Rz = C890.   3892 = line similar to C890 but with one fewer backcrosses to C790 and a higher frequency of Rz.   3859m = C859.   3865 = popn similar to C310 (popn-755) with Rz.   3893 = mmaaRz x composite of susceptible mm, O-T inbreds.   3894 = composite of Rzmmaa mother root selections.

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TEST 1694. EVALUATION OF MULTIGERM GERMPLASM UNDER VIRUS YELLOWS CONDITIONS, SALINAS, CA., 1994

24 entries x 8 replications, RCB (equalized)
1-row plots, 21 ft. long

Planted: March 14, 1994
BYV/BWYV Inoc: June 9, 1994
Harvested: October 5, 1994

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Virus Yellows %	Beets/100' No.	Powdery Mildew %	Root Rot %	RJAP %
268	Inc. 768 (US 75)	5710	25.13	11.35	6.2	126	8.6	0.0	79.2
Y347	YR-ER-PM Y147	9130	31.75	14.38	4.1	129	5.5	0.0	79.2
U86-46/2	Inc. C46/2 (86342)	7534	27.52	13.71	4.2	123	6.4	0.0	79.7
R378	RZM R278, R278Y	7920	28.45	13.93	4.8	117	7.9	0.0	78.7
R380	RZM R280, R280Y	8945	31.90	14.05	4.8	127	6.9	0.0	80.2
R370	RZM R270Y	9581	35.12	13.65	4.8	118	7.0	0.0	79.4
Y339	YR-ER-PMR Y139 (C39)	9360	30.38	15.43	4.3	126	2.8	0.0	81.5
R322Y3 (%)	YR-ER-PMR R122Y2 (%S)	10508	35.55	14.77	3.8	133	7.4	0.0	79.1
F86-31/6	Inc. C31/6 (L86263)	9351	31.91	14.68	3.7	131	7.0	0.0	80.8
R381-43	RZM R281-43	10038	35.95	13.98	4.5	125	6.7	0.0	80.4
R381-89	RZM R281-8911	10116	35.39	14.34	4.0	111	6.3	0.0	80.6
R376-43-#(C)	Inc. R176-43-#(C76-43)	10609	36.56	14.52	3.6	128	6.1	0.0	80.8
R376-43-14	Inc. R176-43-14	9346	33.78	13.84	3.8	129	7.4	0.0	81.0
R376-43-15	Inc. R176-43-15	8398	29.00	14.48	4.5	112	4.3	0.0	80.6
R376-89-#(C)	Inc. R176-89-#(C76-89)	10400	35.93	14.48	4.6	121	6.9	0.4	81.6
R376-89-5	Inc. R176-89-5	9547	32.38	14.76	3.5	128	7.1	0.0	77.9
R376-89-18	Inc. R176-89-18	10055	34.76	14.45	3.6	117	6.5	0.0	81.8
KWS 6770	High % S check	8000	28.18	14.19	8.2	109	6.3	0.0	79.7
3911	YR-ER-PMR Popn-911 (A,aa)	9368	32.98	14.19	4.3	118	4.9	0.4	81.5
3915	2915,...,2911Yaa x A	9963	36.18	13.71	4.0	123	7.4	0.0	80.7
3918	1913-#,1915-#aa x A (C918)	9809	34.94	14.04	4.0	110	7.1	0.0	79.8
3916	RZM 2916 (A,aa)	8707	32.10	13.56	3.8	131	8.0	0.0	79.5
Z330	RZM Z230 (A,aa)	9260	32.90	14.07	6.4	114	8.3	0.0	78.8
N203H15	2915aa x C03,C03-1	9198	40.03	11.55	5.1	124	8.7	0.0	80.3
Mean		9202.2	32.87	14.00	4.5	122.0	6.7	0.0	80.1
LSD (.05)		818.6	2.48	0.62	0.6	14.3	0.8	0.4	2.0
C.V. (%)		9.0	7.66	4.52	13.8	11.9	12.5	984.1	2.6
F value		14.0**	1.80**	16.03**	24.3**	2.0*	21.1**	0.9NS	2.0*

See Test 1394 for corresponding entries under non-virus yellows inoculated conditions and descriptions. Test 4594 under moderate rhizomania conditions.

TEST 1794. VIRUS YELLOWS EVALUATION OF HYBRIDS, SALINAS, CA., 1994

24 entries x 8 replications, RCB (equalized)
1-row plots, 21 ft. long

Planted: March 14, 1994
BYV/BWYV inoc: June 9, 1994
Harvested: September 29, 1994

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew %	Virus Yellows %	RJAP %
6770	High % S check	7883	27.09	14.54	0.5	122	7.1	8.3	82.4
4454	Comm. check	9913	35.75	13.86	0.0	133	6.5	5.8	81.0
R380H8	F82-546H3 x R280,Y	8522	31.25	13.64	0.0	127	8.8	6.0	81.3
R380H46	92-790- 6CMS x R280,Y	9581	34.75	13.76	0.0	131	8.1	5.2	80.7
R380H50	92-790-15CMS x R280,Y	9541	34.15	13.96	0.0	120	7.8	5.2	81.4
R380H54	92-790-54CMS x R280,Y	8897	31.64	14.02	0.7	126	8.0	4.9	80.5
R380H89	88-790-68CMS x R280,Y	9029	32.28	13.98	0.0	126	8.3	5.3	81.1
R380H51	92-790-15H26 x R280,Y	9632	34.15	14.10	0.0	134	8.0	5.7	80.5
R380H52	92-790-15H39 x R280,Y	9889	36.20	13.66	0.0	128	7.9	5.6	80.4
R380H53	92-790-15H97 x R280,Y	10374	36.97	14.04	0.0	125	7.7	5.6	81.6
R380H59	2859m(Sp)aa x R280,Y	8751	32.83	13.34	0.0	130	8.6	5.8	78.5
R380H93	2890(Sp)aa x R280,Y	9353	34.10	13.73	0.0	138	8.1	5.5	82.9
R376H52	F92-790-15H39 x R276,Y	10081	37.38	13.50	0.0	130	7.3	5.0	82.4
R384H50	F92-790-15CMS x R176-43,-89-#	10415	36.82	14.15	0.0	130	7.4	4.9	81.2
R384H51	F92-790-15H26 x R176-43,-89-#	10578	36.85	14.36	0.0	137	7.8	5.1	81.3
R384H52	F92-790-15H39 x R176-43,-89-#	10124	36.37	13.91	0.0	142	7.3	4.8	81.8
R378H46	F92-790-6CMS x R278,Y	9017	33.57	13.49	0.0	126	7.8	5.3	81.1
R378H50	F92-790-15CMS x R278,Y	9669	34.65	13.95	0.0	136	7.8	5.1	82.1
R378H52	F92-790-15H39 x R278,Y	9619	34.77	13.84	0.0	134	7.6	5.3	81.5
R378H54	F92-790-54CMS x R278,Y	9101	32.56	13.99	0.0	134	8.0	4.8	81.8
3915H52	F92-790-15H39 x 2915,...,2911	9830	35.30	13.94	0.0	136	7.4	4.8	80.9
3918H52	F97-790-15H39 x 1913-#,1915-#	10324	37.25	13.82	0.0	125	7.6	5.0	80.3
R338H52	F92-790-15H39 x R38-#	9393	35.13	13.32	0.0	131	8.4	5.7	78.9
N303H52	F92-790-15H39 x C603,C603-1	8255	39.58	10.39	0.4	136	9.0	6.4	77.6
Mean		9490.5	34.64	13.72	0.1	130.8	7.8	5.5	81.0
LSD (.05)		806.1	2.41	0.61	0.5	13.6	1.1	0.5	2.1
C.V. (%)		8.6	7.05	4.53	805.6	10.6	13.8	8.8	2.7
F value		5.9**	8.96**	12.17**	0.9NS	1.3NS	2.1**	18.4**	2.5**

See Test 994 for entries that correspond to entries 1-12; Test 894 for entries that correspond to entries 13-24.

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TEST 894. EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1994

Planted: February 15, 1994
Harvested: September 19, 1994

32 entries x 8 replications, RCB (equalized)
1-row plots, 31 ft. long

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew %	Bolting %	RJAP %
4454	Comm. check	15881	47.64	16.66	0.0	151	2.4	0.0	84.4
KWS 6770	High % S check	15020	41.06	18.27	0.3	140	4.3	0.0	87.5
R380H50	F92-790-15CMS x R280,Y	15926	49.12	16.21	0.0	149	3.5	0.0	84.1
R380H52	F92-790-15H39 x R280,Y	15758	49.65	15.88	0.0	142	4.8	0.3	84.4
R376H39	91-762-17CMS x R276,Y	15598	50.11	15.56	0.3	145	5.1	0.0	84.9
R376H46	F92-790- 6CMS x R276,Y	15323	48.64	15.76	0.6	129	3.8	0.3	83.8
R376H50	F92-790-15CMS x R276,Y	15282	48.00	15.93	0.5	146	3.6	0.0	84.9
R376H51	F92-790-15H26 x R276,Y	14927	45.74	16.31	0.0	145	4.3	0.0	85.3
R376H52	F92-790-15H39 x R276,Y	16127	52.10	15.48	0.3	136	4.6	0.5	85.4
R376H53	F92-790-15H97 x R276,Y	16254	50.68	16.05	0.0	149	4.7	0.0	85.0
R376H54	F92-790-54CMS x R276,Y	15746	49.24	15.99	0.3	139	4.1	0.6	85.7
R384H50	F92-790-15CMS x R176-43,89-#	16244	50.44	16.11	0.0	141	3.3	0.0	84.8
R384H51	F92-790-15H26 x R176-43,89-#	15387	46.06	16.71	0.0	146	4.2	0.0	84.4
R384H52	F92-790-15H39 x R176-43,89-#	15479	48.41	15.98	0.2	155	2.9	0.0	84.5
R376H8	F82-546H3 x R276,Y	14635	45.64	16.02	0.0	143	5.2	0.0	84.2
R378H8	F82-546H3 x R278,Y	14380	43.87	16.39	0.0	149	4.3	0.0	85.0
R378H39	91-762-17CMS x R278,Y	16011	49.93	16.02	0.0	156	4.3	0.3	86.3
R378H46	F92-790-6CMS x R278,Y	15883	47.87	16.60	0.0	143	3.4	0.0	85.9
R378H50	F92-790-15CMS x R278,Y	15965	48.71	16.40	0.0	150	3.4	0.3	84.6
R378H52	F92-790-15H39 x R278,Y	15707	48.29	16.27	0.0	152	3.6	0.0	85.2
R378H54	F92-790-54CMS x R278,Y	15219	46.50	16.36	0.0	151	3.9	0.0	84.5
3915H20	87-309H3 x 2915,...,2911	14381	44.65	16.11	0.0	147	5.5	0.0	83.9
3915H39	91-762-17CMS x 2915,...,2911	15783	50.85	15.50	0.0	141	4.4	0.0	85.0
3915H46	F92-790-6CMS x 2915,...,2911	15741	49.99	15.75	0.0	148	4.1	0.0	84.2

TEST 894.   EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1994

(cont.)

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew %	Bolting %	RJAP %
3915H50	F92-790-15CMS x 2915,...,2911	16285	51.88	15.71	0.0	149	3.9	0.0	84.7
3915H52	F92-790-15H39 x 2915,...,2911	15773	50.43	15.65	0.0	138	3.9	0.0	84.5
3915H54	F92-790-54CMS x 2915,...,2911	15638	49.72	15.74	0.6	145	4.6	0.0	85.7
3918H39	91-762-17CMS x 1913,1915-#	15262	48.34	15.80	0.0	141	5.0	0.0	84.9
3918H50	F92-790-15CMS x 1913,1915-#	15715	48.68	16.15	0.0	144	3.9	0.0	84.5
3918H52	F97-790-15H39 x 1913,1915-#	15778	49.38	15.99	0.0	144	3.3	0.0	84.0
R338H52	F92-790-15H39 x R38-#	15344	48.83	15.73	0.0	142	5.2	0.3	84.3
N303H52	F92-790-15H39 x N103-1	14133	52.13	13.63	8.8	139	7.1	0.0	83.1
Mean		15518.3	48.52	16.02	0.4	144.9	4.2	0.1	84.8
LSD (.05)		891.3	2.64	0.50	1.4	12.8	1.1	0.5	2.0
C.V. (%)		5.8	5.51	3.18	377.9	9.0	25.3	632.3	2.4
F value		3.0**	6.70**	13.97**	9.8**	1.5NS	5.3**	0.8NS	1.2NS

See Test 1794 for performance under virus yellows conditions. Test 4494 for performance under rhizomania conditions.

[1]R280,Y = C54Rz. R276,Y = C31/6Rz. R176-43,-89-# = C31-43,-89Rz = C82. R276,Y = C31/6Rz. R278,Y = C46/2Rz.
2911,...,2915 = popn-915 composite. 1913,1915-# = composite of S_1 lines = C918. R38-# = composite of sources of
resistance in C37. N103-1 = C603-1 homozygous cyst nematode resistant line. Codes for F_1CMS hybrids are:
HO = CMS; H39 = C762-17CMS x T-O; H26 = C309CMS x T-O; H97 = C796-43CMS x T-O; H3 = C562HO x T-O.

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TEST 994. EVALUATION OF HYBRID PERFORMANCE OF MONOGERM LINES, SALINAS, CA., 1994

Planted: February 15, 1994
Harvested: September 14, 1994

32 entries x 8 replications, RCB (equalized)
1-row plots, 31 ft. long

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew %	Bolting %	RJAP %
KWS 6770	High % S check	15806	43.04	18.36	0.0	141	4.1	0.0	84.9
4454	Comm. check	15349	46.95	16.36	0.0	150	2.8	0.0	84.8
R380H72	83-718HO x R280,Y	14591	48.78	15.00	0.3	146	4.7	0.0	84.1
R380H3	F82-562HO x R280,Y	13911	43.63	15.94	0.0	151	4.7	0.0	84.7
R380H20	87-309H3 x R280,Y	13560	43.50	15.60	0.0	138	4.3	0.3	84.0
R380H26	87-309CMS x R280,Y	13851	44.27	15.65	0.0	153	5.0	0.0	83.6
R380H97	C796-43HO x R280,Y	13249	40.92	16.20	0.0	143	5.0	0.0	84.2
R380H8	F82-546H3 x R280,Y	14429	45.60	15.85	0.0	147	4.9	0.0	84.4
R380H39	91-762-17CMS x R280,Y	15028	48.14	15.63	0.0	156	4.1	0.0	83.7
R380H89	88-790-68CMS x R280,Y	14558	45.77	15.93	0.0	143	3.6	0.0	84.1
R380H46	92-790- 6CMS x R280,Y	14766	47.42	15.56	0.0	145	3.3	0.0	85.3
R380H50	92-790-15CMS x R280,Y	15150	48.20	15.71	0.2	157	4.2	0.0	84.9
R380H54	92-790-54CMS x R280,Y	15394	48.41	15.93	0.3	149	3.6	0.0	84.0
R380H18	88-790-68H26 x R280,Y	14590	46.00	15.85	0.3	149	4.8	0.0	85.5
R380H47	92-790- 6H26 x R280,Y	13827	44.34	15.68	0.0	141	5.2	0.0	85.0
R380H51	92-790-15H26 x R280,Y	14623	46.17	15.85	0.0	151	3.9	0.0	84.4
R380H55	F92-790-54H26 x R280,Y	15119	48.64	15.56	0.0	146	3.4	0.0	85.1
R380H48	F92-790- 6H39 x R280,Y	14708	48.44	15.19	0.0	146	3.1	0.0	83.9
R380H52	F92-790-15H39 x R280,Y	14579	46.93	15.59	0.0	143	3.9	0.0	84.2
R380H56	F92-790-54H39 x R280,Y	15317	48.92	15.66	0.0	156	3.9	0.0	86.0
R380H49	F92-790- 6H97 x R280,Y	14361	46.51	15.49	0.0	151	4.8	0.0	84.7
R380H53	F92-790-15H97 x R280,Y	14067	45.83	15.39	0.0	146	3.5	0.0	84.1
R380H57	F92-790-54H97 x R280,Y	14416	46.48	15.55	0.0	152	3.8	0.0	84.9
R380H59	2859m(Sp)aa x R280,Y	13933	43.87	15.89	0.0	157	4.3	0.0	85.5

TEST 994. EVALUATION OF HYBRID PERFORMANCE OF MONOGERM LINES, SALINAS, CA., 1994

(cont.)

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/100' No.	Powdery Mildew %	Bolting %	RJAP %
R380H65	2865m(Sp)aa x R280,Y	13559	42.99	15.79	0.0	144	5.1	0.0	83.3
R380H67	2867m(Sp)aa x R280,Y	13880	45.50	15.24	0.6	142	3.7	0.0	83.9
R380H87	2889maa x R280,Y	13742	45.16	15.23	0.0	137	4.3	0.0	82.7
R380H88	2888maa x R280,Y	14283	46.08	15.55	0.0	148	3.9	0.3	83.7
R380H91	2891aa x R280,Y	13999	44.49	15.76	1.5	138	4.4	0.0	84.3
R380H93	2890(Sp)aa x R280,Y	14912	48.28	15.48	0.0	154	4.1	0.0	85.1
3918H20	87-309H3 x 1913,1915-#	13099	42.32	15.51	0.0	154	5.2	0.0	82.1
3918H50	92-790-15CMS x 1913,1915-#	15017	47.30	15.89	0.0	144	2.8	0.0	85.0
Mean		14430.7	45.90	15.75	0.1	147.4	4.1	0.0	84.4
LSD (.05)		894.8	2.81	0.46	0.5	12.2	1.3	0.2	1.8
C.V. (%)		6.3	6.22	2.94	500.6	8.4	31.9	1136.6	2.2
F value		4.3**	4.38**	11.54**	2.8**	1.7	2.1**	25.7NS	1.6NS

See Test 1794 for performance under virus yellows conditions.

[1]R280,Y = R280 & R280Y = versions of C54Rz. 1913,1915-# = composites of selected S₁ lines similar to C918.
Codes for F₁CMS hybrids are: HO = CMS; H3 = C562CMS x T-O; H26 = C309CMS x T-O; H39 = C762-17CMS x T-O;
H97 = C796-43CMS x T-O. 2859 = C859. 2890 = C890.

TEST 4494. RHIZOMANIA EVALUATION OF USDA EXPERIMENTAL HYBRIDS, SALINAS, CA., 1994

32 entries x 8 reps., RCB (equalized)
1-row plots, 20 ft. long

Planted: May 10, 1994
Harvested: October 12, 1994

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Powdery Mildew %	Root Rot %	RJAP %
US H11	L113401	5215	19.90	13.11	174	7.0	0.0	86.9
Rizor	RZ3/1022 (1/93), SES	8146	25.94	15.70	160	6.8	0.0	81.6
Rhizosen	L493304, Holly	6454	23.87	13.49	171	6.1	0.0	85.5
SS-289R	5/2/94, Spreckels	7071	24.28	14.55	185	6.8	0.0	84.8
4581	3072 (2/94), Betaseed	8176	26.97	15.18	173	5.0	0.0	83.4
KWS 6770	30161365MN (2/94)	6419	21.53	14.89	162	5.6	0.0	84.8
Rhizoguard	Holly	6591	23.99	13.74	164	6.4	0.0	84.6
Rima	RN3-1021 (1/93), SES	8499	27.05	15.70	156	6.1	0.4	84.0
N303H15	2915aa x C603,C603-1	7650	29.30	13.05	154	6.3	0.4	83.2
R338H52	F92-790-15H39 x R38(C)	7474	27.09	13.82	158	5.8	0.0	84.5
R338H65	2865m(Sp)aa x R38(C)	7305	25.94	14.05	172	6.8	0.0	83.0
R378H20	U87-309H3 x R278,Y	7592	26.46	14.36	167	6.3	0.0	83.8
R378H52	F92-790-15H39 x R278,Y	8010	28.53	14.04	163	3.4	0.0	84.6
R380H20	U87-309H3 x R280,Y	7926	27.88	14.21	174	6.3	0.4	83.1
R380H52	F92-790-15H39 x R280,Y	8034	28.32	14.19	173	4.1	0.0	84.1
R380H67	2867m(Sp)aa x R280,Y	8591	30.16	14.24	164	5.4	0.0	85.5
R380H50	F92-790-15CMS x R280,Y	8485	29.24	14.50	169	3.6	0.0	84.9
R380H51	F92-790-15H26 x R280,Y	8338	28.99	14.39	166	4.9	0.0	83.2
R380H59	2859m(Sp)aa x R280,Y	8018	27.88	14.38	163	6.3	0.0	84.0
R380H65	2865m(Sp)aa x R280,Y	7879	27.67	14.25	161	6.3	0.0	84.4
R384H20	U87-309H3 x R176-43;-89-#	6426	22.89	14.04	181	6.3	0.0	83.8
R384H51	F92-790-15H26 x " " "	6921	24.73	13.99	181	5.0	0.0	83.9
R384H52	F92-790-15H39 x " " "	7433	27.26	13.65	165	3.9	0.0	85.6
3915H20	U87-309H3 x 2911,...,2915	7806	27.83	14.05	166	6.8	0.0	83.4

TEST 4494. RHIZOMANIA EVALUATION OF USDA EXPERIMENTAL HYBRIDS, SALINAS, CA., 1994

(cont.)

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Powdery Mildew %	Root Rot %	RJAP %
3915H52	F92-790-15H39 x 2911,...,2915	8185	29.89	13.71	161	3.2	0.0	83.4
3915H65	2865m(Sp)aa x 2911,...,2915	8259	28.88	14.29	154	5.0	0.0	83.3
3918H52	F92-790-15H39 x 1913-#,1915-#	7978	28.91	13.80	159	3.4	0.0	83.7
R376-43-CH20	U87-309H3 x R176-43-#(C)	6858	24.34	14.13	169	6.3	0.0	85.3
R376-89-CH20	U87-309H3 x R176-89-#(C)	5907	21.16	14.01	177	6.9	0.0	83.6
R376H50	F92-790-15CMS x R276,Y	8006	28.32	14.11	161	4.3	0.0	83.9
R380H93	2890aa x R280,Y	8304	29.24	14.19	171	5.5	0.0	83.8
N303H52	F92-790-15H39 x C603,C603-1	6017	25.83	11.66	163	6.6	0.4	84.1
Mean		7499.2	26.57	14.11	166.8	5.6	0.1	84.1
LSD (.05)		637.7	2.11	0.46	12.3	0.8	0.4	2.0
C.V. (%)		8.6	8.06	3.34	7.5	15.1	805.9	2.4
F value		14.4**	12.45**	19.38**	3.1**	15.6**	0.9NS	2.0**

See Tests 894, 994, and 1794 for performance under nondiseased and virus yellows infected conditions. Test 4494 is under moderate rhizomania conditions in which only about half of the fully susceptible roots would be rates as susceptible (scores 5-9). The roots in this these tests were not individually scored, but on the basis of the relationship between root scores (% resistant) and sugar yield for tests 4194 & 4294, it is likely that sugar yield is a good predictor of the level or frequency of resistance to rhizomania in these hybrids. Hybrids such as R380H67, R380H59, 3915H65, and R380H93 that had resistant contributions from both parents had relatively high sugar yield. Hybrids that involved C76-43 & C76-89 had a relatively low frequency of the Rz allele and did not perform as well.

[1]See Tests 894 and 994 for descriptions of lines and hybrids.

TEST 1094. EVALUATION OF HYBRIDS OF LINES FROM POPNS-909,-911 & -913, SALINAS, CA., 1994

Planted: February 14, 1994
Harvested: September 22, 1994

16 entries x 8 replications, RCB (equalized)
1-row plots, 31 ft. long

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew %	RJAP %
KWS 6770	High % S check	16988	45.70	18.61	0.0	146	3.1	85.3
4454	Comm. check	16664	50.68	16.45	0.0	146	1.8	85.5
R380H50	F92-790-15CMS x R280,Y	16690	52.19	15.99	0.0	147	2.6	85.6
R384H50	F92-790-15CMS x R176-43,-89-#	16503	50.62	16.29	0.0	143	2.7	86.8
3915H50	F92-790-15CMS x 2915,...,2911	15192	48.27	15.75	0.0	146	2.8	85.1
3918H50	F92-790-15CMS x 1913,1915-#	16052	50.27	15.96	0.0	136	2.9	85.3
3909-34H50	F92-790-15CMS x 0909-34	16809	52.03	16.16	0.0	139	2.2	86.3
3909-37H50	F92-790-15CMS x 0909-37	16657	52.74	15.80	0.6	140	1.0	87.4
3911- 4H50	F92-790-15CMS x 2911- 4	15640	49.08	15.93	0.0	133	2.3	86.1
3911-12H50	F92-790-15CMS x 2911-12	15765	49.02	16.09	0.0	137	2.7	84.8
3911-14H50	F92-790-15CMS x 2911-14	16458	51.46	16.00	0.0	137	2.1	85.7
3911-50H50	F92-790-15CMS x 2911-50	16573	52.51	15.79	0.0	151	1.7	86.0
3913- 5H50	F92-790-15CMS x 2913- 5	15955	51.69	15.44	0.0	152	2.6	85.2
3913-18H50	F92-790-15CMS x 2913-18	15931	50.81	15.55	0.0	143	1.4	83.0
3913-22H50	F92-790-15CMS x 2913-22	15456	48.33	16.00	0.0	135	2.4	86.0
3913-25H50	F92-790-15CMS x 2913-25	16028	50.91	15.75	0.7	134	1.4	85.6
Mean		16210.1	50.40	16.10	0.1	141.6	2.2	85.6
LSD (.05)		1137.2	2.94	0.71	0.7	10.2	1.4	3.1
C.V. (%)		7.1	5.89	4.43	813.8	7.3	61.6	3.6
F value		1.7NS	3.26**	8.09**	0.9NS	2.7NS	1.6NS	0.8NS

See Test 1894 for performance under virus yellows conditions.

[1]R280,Y = versions of C54Rz. R176-43,-89-# = C31-43,-89Rz = C82. 2911,...,2915 = popn-915. 1913,1915-# = selected S₁ lines = C918. 0909-34 = C909-34; 0909-37 = C909-37; 2911-4 = C911-4; 2911-12 = C911-12; 2911-14 = C911-14; 2911-50 = C911-50. 2913-5,-18,-22, & -25 = lines selected from popn-913.

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TEST 1494. EVALUATION OF HYBRIDS WITH SELECTED PROGENY FAMILIES, SALINAS, CA., 1994

Planted: February 15, 1994
Harvested: September 20, 1994

48 entries x 8 replications, RCB (equalized); 3 sets, 16 X 8 (equalized)
1-row plots, 21 ft. long

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/100' No.	Powdery Mildew %	Bolting %	RJAP %
Test 1494-1: 16 varieties x 8 reps (RCB)									
KWS 6770	High % S check	15386	42.10	18.36	0.4	130	5.9	0.0	84.4
US H11	L113401	13980	43.42	16.13	0.0	139	7.4	0.0	85.9
4454	Comm. check	16085	47.80	16.85	0.9	137	4.3	0.0	84.2
R384H52	F92-790-15H39 x R176-43,89-#	16551	51.16	16.19	0.9	131	5.0	0.0	83.9
3918H52	F92-790-15H39 x 1913,1915-#	15502	47.95	16.17	0.0	136	4.5	0.0	83.3
3915H20	87-309H3 x 2915,...,2911	14561	46.10	15.79	0.0	149	6.9	0.0	83.3
3978H20	87-309H3 x R278,Y	14221	42.60	16.69	0.0	148	6.8	0.0	83.5
3980H20	87-309H3 x R280,Y	14213	42.64	16.67	0.0	136	6.5	0.4	84.2
R384H20	87-309H3 x R176-43,-89-#	14650	43.97	16.67	0.9	148	5.9	0.0	84.4
R376H20	87-309H3 x R276,Y	14092	42.60	16.54	0.0	137	6.4	0.0	84.8
R376-43-14H20	89-309H3 x R176-43-14	15105	45.45	16.61	0.4	136	6.5	0.0	85.2
R376-43-15H20	89-309H3 x R176-43-15	13917	41.06	16.95	0.0	139	5.3	0.0	83.7
R376-43-CH20	89-309H3 x R176-43-#(C)	15277	45.70	16.73	0.0	137	6.1	0.0	84.7
R376-89-5H20	89-309H3 x R176-89-5	14126	41.54	17.01	0.0	133	6.0	0.0	83.5
R376-89-18H20	89-309H3 x R176-89-18	14259	42.50	16.79	0.0	137	6.4	0.0	84.2
R376-89-CH20	89-309H3 x R176-89-#(C)	13799	41.00	16.84	0.0	142	6.3	0.0	84.0
Mean		14732.8	44.22	46.69	0.2	138.5	6.0	0.0	84.2
LSD (.05)		864.8	2.70	0.42	1.0	10.8	0.8	0.3	1.7
C.V. (%)		5.9	6.16	2.56	474.9	7.9	12.94	1128.6	2.1
F value		7.2**	9.07**	13.72**	1.0NS	2.2NS	9.8**	1.0NS	1.3NS

TEST 1494. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES, SALINAS, CA., 1994

48 entries x 8 replications, RCB (equalized). ANOVA to compare means across sets of entries.

		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/100' No.	Powdery Mildew %	Bolting %	RJAP %
Mean		14498.6	44.10	16.46	0.1	140.3	6.4	0.0	83.7
LSD (.05)		885.0	2.68	0.45	0.6	12.8	0.8	0.3	1.8
C.V. (%)		6.2	6.17	2.75	776.6	9.3	12.3	1433.0	2.1
F value		4.9**	5.60**	7.59**	1.1NS	1.9**	7.3**	1.0NS	1.7*

See Tests 1894 & 1994 for performance of same entries under virus yellows conditions.

[1]790-15H39 = C762-17CMS x C790-15. 309H3 = C562HO x C309. R176-43,-89-# = C76-43,-89 = C82. 1913,1915-# = C918. 2911,...,2915 = popn-915. R278,Y = C46/2Rz. R280,Y = C54Rz. R276,Y = C31/6Rz. R176-43-14,-15 = FS families from C76-43. R176-43-# = C76-43. R176-89-5,-18 = FS families from C76-89. R176-89-# = C76-89.

TEST 1494. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES, SALINAS, CA., 1994

(cont.)

Variety	Description[2]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/100' No.	Powdery Mildew %	Bolting %	RJAP %
Test 1494-2: 16 varieties x 8 reps (RCB)									
3918H2O	87-309H3 x 1913,1915-#	14468	44.55	16.27	--	142	6.5	--	83.8
3918-#(C)H2O	87-309H3 x 1913,1915-#	14053	42.30	16.65	--	137	6.6	--	84.3
3913-3H2O	87-309H3 x 1913-3(S₁)	15883	46.85	16.98	--	146	6.0	--	83.8
3913-51H2O	87-309H3 x 1913-51(S₁)	15593	48.25	16.16	--	145	5.5	--	82.4
3913-70H2O	87-309H3 x 1913-70(S₁)	15005	44.58	16.84	--	154	5.9	--	83.4
3913-71H2O	87-309H3 x 1913-71(S₁)	15049	47.26	15.94	--	144	7.4	--	84.2
3909-34H2O	87-309H3 x 0909-34	14604	44.71	16.34	--	145	6.3	--	85.0
3909-37H2O	87-309H3 x 0909-37	14516	44.30	16.40	--	149	4.5	--	84.0
3911-4H2O	87-309H3 x 2911-4	14685	44.03	16.67	--	137	6.9	--	84.0
3911-12H2O	87-309H3 X 2911-12	13959	43.90	15.91	--	145	6.5	--	82.8
3911-14H2O	87-309H3 x 2911-14	13990	41.95	16.67	--	143	7.0	--	83.1
3911-50H2O	87-309H3 x 2911-50	15009	46.88	16.02	--	150	6.8	--	82.2
3913-5H2O	87-309H3 x 2913-5	14423	45.05	16.00	--	149	6.9	--	82.7
3913-18H2O	87-309H3 x 2913-18	14814	45.00	16.50	--	149	6.3	--	83.3
3913-22H2O	87-309H3 x 2913-22	14933	45.75	16.33	--	144	6.5	--	82.7
3913-25H2O	87-309H3 x 2913-25	13737	42.36	16.23	--	136	6.1	--	82.8
Mean		14669.9	44.86	16.37	--	144.7	6.3	--	83.4
LSD (.05)		879.8	2.67	0.45	--	13.9	0.7	--	2.0
C.V. (%)		6.1	6.01	2.75	--	9.7	10.5	--	2.4
F value		3.5**	3.63**	4.19**	--	1.1NS	8.3**	--	1.2NS

[2]309H3 = C562HO x C309 used as tester. 1913,1915-# = S₁ families selected and composited to produce C918. 1913-#(S₁) = S₁ progenies selected from popn-913. 0909-34 & -37 = C909-34 & C909-37. 2911-# = C911-4, C911-12, C911-14, & C911-50. 2913-# = families selected from popn-913.

TEST 1494. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES, SALINAS, CA., 1994

(cont.)

Variety	Description[3]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew %	Bolting %	RJAP %
Test 1494-3: 16 varieties x 8 reps (RCB)									
3911-1H20	87-309H3 x RZM 0911-1	14799	45.95	16.15	--	146	6.8	--	84.6
3911-4(B)H20	87-309H3 x RZM 0911-4(B)	13787	41.30	16.71	--	139	7.4	--	82.3
3911-24H20	87-309H3 x RZM 2911-24	14190	44.13	16.09	--	141	7.5	--	83.6
3913-6H20	87-309H3 x RZM 0913-6	13173	39.95	16.51	--	133	7.3	--	83.4
3913-9H20	87-309H3 x RZM 2913-9	13567	43.10	15.76	--	143	6.8	--	82.3
3915-1H20	87-309H3 x RZM 0915-1	14248	43.61	16.33	--	133	6.1	--	82.9
3915-4H20	87-309H3 x RZM 2915-4	14597	44.26	16.49	--	136	7.1	--	83.0
3915-6H20	87-309H3 x RZM 0915-6	14010	43.10	16.25	--	133	6.9	--	83.8
3915-7H20	87-309H3 x RZM 2915-7	14071	42.51	16.59	--	130	6.9	--	82.5
3915-16H20	87-309H3 x RZM 0915-16	13226	42.10	15.71	--	136	5.9	--	83.8
3915-22H20	87-309H3 x RZM 0915-22	14547	44.15	16.48	--	134	6.3	--	83.7
3915-23H20	87-309H3 x RZM 0915-23	14423	43.83	16.48	--	145	7.3	--	83.0
3915-24H20	87-309H3 x RZM 0915-24	14522	45.40	16.00	--	152	7.0	--	82.8
3915-27H20	87-309H3 x RZM 0915-27	14818	45.75	16.21	--	134	6.4	--	83.5
3915-34H20	87-309H3 x RZM 0915-34	13851	42.11	16.48	--	136	6.6	--	83.8
3915-46H20	87-309H3 x RZM 2915-46	13662	40.55	16.89	--	130	6.6	--	84.5
Mean		14093.1	43.24	16.32	--	137.7	6.8	--	83.4
LSD (.05)		846.1	2.63	0.44	--	13.7	0.7	--	1.6
C.V. (%)		6.1	6.13	2.74	--	10.1	10.2	--	1.9
F value		2.9*	3.52*	4.17**	--	1.6NS	3.6**	--	1.5NS

[3]309H3 = C562HO x C309 used as tester. Pollinators are families selected from popns-911, -913, & -915.

TEST 1894. VIRUS YELLOW EVALUATION OF HYBRIDS WITH PROGENY SELECTIONS, SALINAS, CA., 1994

Planted: March 14, 1994
BYV/BWVY Inoc: June 9, 1994
Harvested: September 29, 1994

24 entries x 8 reps., RCB (equalized)
1-row plots, 21 ft. long

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Virus Yellows %	Beets/100' No.	Powdery Mildew %	RJAP %
KWS 6770	High % S check	7590	27.24	13.93	8.2	118	7.7	82.3
4454	Comm. check	9908	35.64	13.91	5.8	122	7.2	81.8
R380H50	F92-790-15CMS x R280,Y	9522	33.61	14.19	4.9	126	7.3	81.6
R384H50	" " x R176-43,-89-#	10390	36.51	14.24	4.4	117	7.0	82.7
3915H50	F92-790-15CMS x 2915,...,2911	9649	34.78	13.88	4.6	112	7.4	80.5
3918H50	" " x 1913,1915-#	9589	35.03	13.69	4.4	115	7.9	79.9
3909-34H50	" " x 0909-34	9186	33.10	13.90	4.4	105	6.8	82.1
3909-37H50	" " x 0909-37	8922	32.84	13.57	4.8	100	5.3	80.7
3911- 4H50	F92-790-15CMS x 2911- 4	9357	34.49	13.64	4.6	98	7.1	80.6
3911-12H50	" " x 2911-12	9960	36.30	13.74	4.5	126	7.6	79.9
3911-14H50	" " x 2911-14	9116	33.32	13.71	5.0	118	7.9	80.7
3911-50H50	" " x 2911-50	9250	34.10	13.59	4.5	121	7.3	80.9
3913- 5H50	F92-790-15CMS x 2913- 5	8470	31.48	13.45	4.6	123	7.8	81.9
3913-18H50	" " x 2913-18	9487	33.42	14.19	4.5	115	7.4	81.9
3913-22H50	" " x 2913-22	9707	34.66	13.98	4.4	113	7.8	81.1
3913-25H50	" " x 2913-25	9376	34.13	13.75	4.5	96	7.4	80.9
R384H20	87-309H3 x R176-43,-89-#	9443	33.94	13.88	5.4	126	8.6	82.5
R376-43-CH20	" x R176-43-#(C)	9215	32.41	14.20	5.3	131	8.8	82.2
R376-43-14H20	" x R176-43-14	9129	32.56	14.04	5.6	128	8.9	82.2
R376-43-15H20	" x R176-43-15	8865	30.75	14.41	5.6	131	8.0	81.3
R376-89-CH20	" x R176-89-#(C)	9384	32.81	14.31	5.5	122	8.9	81.5
R376-89-5H20	" x R176-89-5	9620	32.35	14.86	5.0	126	8.9	81.0
R376-89-18H20	" x R176-89-18	10042	35.15	14.32	5.1	129	8.8	82.7
3918H20	" x 1913-#,1915-#	9433	33.40	14.14	5.1	128	8.9	79.9
Mean		9358.7	33.50	13.98	5.0	118.5	7.8	81.4
LSD (.05)		809.8	2.60	0.57	0.5	16.8	0.7	1.7
C.V. (%)		8.8	7.87	4.11	9.2	14.3	8.8	2.1
F value		3.7**	4.35**	2.58**	24.6**	2.9**	12.7**	2.1**

See Test 1094 for corresponding entries 1-16 under nonvirus yellows conditions and Test 1494 for entries 17-24.

TEST 1994. VIRUS YELLOWS EVALUATION OF HYBRIDS WITH -911, -913, & -915 PROGENIES, SALINAS, CA., 1994

24 entries x 8 replications, RCB (equalized)
1-row plots, 21 ft. long

Planted: March 14, 1994
BYV/BWYV Inoc: June 9, 1994
Harvested: October 3, 1994

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Virus Yellows %	Beets/ 100' No.	Powdery Mildew %	RJAP %
4454	Comm. check	9726	35.30	13.81	5.6	143	6.6	79.7
KWS 6770	High % sugar check	7959	27.16	14.65	7.6	138	7.3	81.2
3918H20	87-309H3 x 1913-#,1915-#	8909	31.88	13.96	4.8	140	8.8	78.9
3918-#(C)H20	87-309H3 x 1913-#,1915-#	8289	29.93	13.85	5.2	144	9.0	80.9
3913-3H20	87-309H3 x 1913-3(S₁)	9001	32.54	13.82	5.1	152	8.9	78.3
3913-51H20	87-309H3 x 1913-51(S₁)	9293	33.80	13.75	4.9	154	8.4	80.4
3913-70H20	87-309H3 x 1913-70(S₁)	8841	30.90	14.29	4.6	143	8.8	79.2
3913-71H20	87-309H3 x 1913-71(S₁)	8416	30.30	13.89	5.0	148	9.0	79.5
3911-1H20	87-309H3 x RZM 0911-1	8585	31.40	13.65	5.4	137	8.8	80.5
3911-4(B)H20	87-309H3 x RZM 0911-4(B)	9052	32.37	13.96	5.8	140	8.9	78.0
3911-24H20	87-309H3 x RZM 2911-24	8009	29.97	13.35	5.6	143	9.0	78.9
3913-6H20	87-309H3 x RZM 0913-6	8861	31.70	13.98	5.1	145	8.9	78.6
3913-9H20	87-309H3 x RZM 2913-9	8186	29.40	13.93	4.3	138	8.9	78.4
3915-1H20	87-309H3 x RZM 0915-1	9554	33.87	14.11	5.5	124	8.8	79.8
3915-4H20	87-309H3 x RZM 2915-4	9071	32.85	13.81	5.6	124	8.9	79.1
3915-6H20	87-309H3 x RZM 0915-6	8240	30.21	13.64	5.8	135	8.9	79.4
3915-7H20	87-309H3 x RZM 2915-7	8253	29.97	13.76	5.4	133	8.9	79.0
3915-16H20	87-309H3 x RZM 0915-16	8068	30.15	13.38	6.4	149	8.8	80.0
3915-22H20	87-309H3 x RZM 0915-22	8368	30.45	13.74	5.6	143	8.5	78.0
3915-23H20	87-309H3 x RZM 0915-23	8637	31.08	13.90	4.6	145	8.8	79.8
3915-24H20	87-309H3 x RZM 0915-24	8259	30.44	13.57	5.5	144	8.9	79.4
3915-27H20	87-309H3 x RZM 0915-27	8688	32.00	13.60	5.2	152	9.0	79.6
3915-34H20	87-309H3 x RZM 0915-34	8065	29.40	13.72	5.6	142	9.0	78.9
3915-46H20	87-309H3 x RZM 2915-46	8310	30.82	13.49	5.8	131	8.9	78.5
Mean		8610.0	31.16	13.82	5.4	141.1	8.7	79.3
LSD (.05)		675.9	2.18	0.46	0.5	13.9	0.4	1.9
C.V. (%)		8.0	15.72	3.37	8.8	10.0	4.3	2.3
F value		4.2**	4.95**	2.89**	15.3**	2.4*	18.6**	1.7*

See Test 1494 for corresponding entries without virus yellows and line descriptions.

TEST 4094. RHIZOMANIA EVALUATION OF MM,S',A:aa,Rz LINES, SALINAS, CA., 1994

Planted: May 10, 1994
Harvested: October 11, 1994

32 entries x 4 reps., RCB (equalized)
1-row plots, 20 ft. long

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Powdery Mildew %	RJAP %
US H11	L113401	6238	23.31	13.38	181	7.1	83.0
3909-34	RZM 0909-34	8053	27.62	14.52	126	1.6	84.7
3909-37	RZM 0909-37	7735	28.25	13.68	138	0.4	81.3
3911-4	2911-4Maa x A	8633	29.23	14.76	151	2.1	83.6
3911-4Am	2911-4mmA	8495	29.73	14.29	133	2.0	81.0
3911-12M	2911-12Maa x A	8557	30.60	13.96	144	2.0	81.8
3911-14M	2911-14Maa x A	8263	27.84	14.86	148	2.5	82.1
3911-50	2911-50aa x A	8083	28.98	13.95	159	2.1	82.7
3913- 5	2913- 5aa x A	7876	28.98	13.59	169	3.0	82.3
3913-18	2913-18aa x A	8110	27.72	14.61	160	3.3	84.6
3913-22	2913-22aa x A	8241	29.68	13.89	148	2.8	80.9
3913-25	2913-25aa x A	7946	28.79	13.84	110	2.0	82.8
3913- 3	Inc. 1913- 3 (S$_1$)	6931	24.47	14.16	174	0.1	81.7
3913-51	Inc. 1913-51 (S$_1$)	6402	22.36	14.30	174	0.1	79.2
3913-70	Inc. 1913-70 (S$_1$)	7574	25.62	14.79	188	2.3	81.2
3913-71	Inc. 1913-71 (S$_1$)	7311	27.20	13.44	170	2.0	81.3
U86-37	Inc. C37, 86443	5361	19.01	14.11	181	7.5	82.2
3913-6	RZM 0913-6 (A,aa)	7971	27.28	14.60	175	3.8	82.2
3913-9	RZM 2913-9 (A,aa)	8179	29.70	13.76	165	1.8	82.4
3915-1	RZM 0915-1 (A,aa)	8715	29.82	14.61	166	3.0	81.6
3915-4	RZM 2915-4 (A,aa)	8691	31.08	13.98	180	3.3	82.0
3915-6	RZM 0915-6 (A,aa)	8557	29.30	14.59	179	1.5	85.2
3915-7	RZM 2918-7 (A,aa)	8663	28.15	15.36	144	1.1	81.6
3915-16	RZM 0915-16(A,aa)	8345	30.24	13.80	161	2.0	80.5

TEST 4094. RHIZOMANIA EVALUATION OF MM,S',A:aa,Rz LINES, SALINAS, CA., 1994

(cont.)

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Powdery Mildew %	RJAP %
3915-22	RZM 0915-22 (A,aa)	8124	27.30	14.88	175	2.3	82.9
3915-23	RZM 0915-23 (A,aa)	8240	29.30	14.06	178	1.3	82.8
3915-24	RZM 0915-24 (A,aa)	8669	33.67	12.89	165	3.9	80.5
3915-27	RZM 0915-27 (A,aa)	8690	30.45	14.29	175	0.3	83.5
3915-34	RZM 0915-34 (A,aa)	7934	27.97	14.19	179	4.0	82.4
3915-46	RZM 2915-46 (A,aa)	7337	25.64	14.30	111	1.3	81.9
5747	4747aa x A (A,aa)	6546	24.89	13.14	173	7.4	81.8
2910-12-1	Inc. 1910-12-1 (RzRz)	7315	25.31	14.48	169	2.5	81.0
Mean		7868.3	27.80	14.16	160.8	2.6	82.1
LSD (.05)		635.5	2.12	0.37	14.0	1.2	2.0
C.V. (%)		8.1	7.68	2.64	8.7	47.2	2.4
F value		6.6**	7.22**	8.54**	8.4**	9.5**	1.7NS

See Tests 1094, 1494, 1894, and 1994 for performance of these lines in hybrids under nondiseased and virus yellows conditions. Test 4794 for hybrids under rhizomania conditions. Tests 4094 & 4794 under moderate rhizomania conditions in which only about 50% of the roots in susceptible checks such as US H11 showed susceptible type (ratings 5 to 9) symptoms on tap root. This was the first year in rhizomania tests after being inoculated in 1993.

[1]See Tests 1094 and 1494 for descriptions. In addition, 5747 = recurrent, rhizomania susceptible parent similar to C37. 2910-12-1 = RzRzS₂ line in 5747 background. aa x A = recombined through genetic ms. A,aa = increase in mass of both fertile and sterile plants.

TEST 4794. RHIZOMANIA EVALUATION OF USDA EXPERIMENTAL HYBRIDS WITH SELF-FERTILE POLLINATORS, SALINAS, CA., 1994

16 entries x 8 reps., RCB
1-row plots, 20 ft. long

Planted: May 11, 1994
Harvested: October 11, 1994

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Powdery Mildew %	RJAP %
SS-289R	5/2/94, Spreckels	7477	23.78	15.73	180	7.2	84.1
4581	4581.3072 (2/94), Betaseed	8395	26.23	16.01	164	5.0	82.8
US H11	L113401	5803	20.86	13.90	179	7.4	84.3
3918H50	F92-790-15CMS x 1913-#,1915-#	8095	27.25	14.84	162	3.6	82.1
3915H50	F92-790-15CMS x 2911,...,2915	8857	29.93	14.76	168	4.3	83.3
3909-34H50	F92-790-15CMS x 0909-34	8298	27.83	14.93	164	5.0	84.4
3909-37H50	F92-790-15CMS x 0909-37	8725	29.55	14.76	157	2.0	84.0
3911-4H50	F92-790-15CMS x 2911-4	8701	28.41	15.31	145	4.0	82.8
3911-12H50	F92-790-15CMS x 2911-12	8901	29.91	14.88	163	3.9	82.6
3911-14H50	F92-790-15CMS x 2911-14	9237	29.72	15.55	174	4.6	84.1
3911-50H50	F92-790-15CMS x 2911-50	8649	30.22	14.31	174	3.2	83.2
3913-5H50	F92-790-15CMS x 2913-5	8331	28.67	14.52	183	4.8	84.0
3913-18H50	F92-790-15CMS x 2913-18	8930	29.78	15.00	161	4.4	85.3
3913-22H50	F92-790-15CMS x 2913-22	9076	30.43	14.91	158	4.8	82.0
3913-25H50	F92-790-15CMS x 2913-25	8112	27.56	14.71	134	3.6	82.7
3915H93	2890(Sp)aa x 2911,...,2915	8928	30.03	14.86	175	5.4	82.9
Mean		8407.2	28.13	14.94	165.0	4.6	83.4
LSD (.05)		731.7	2.18	0.62	14.0	1.1	2.2
C.V. (%)		8.8	7.83	4.17	8.6	24.2	2.6
F value		10.0**	11.41**	5.59**	6.7**	12.1**	1.4NS

See Tests 1094, 1494, 1894, & 1994 for performance of these hybrids under nondiseased and virus yellows conditions. Test 4094 for performance of the pollinator lines under rhizomania. Test 4794 under moderate rhizomania conditions.

[1]1913-#,1915-# = composite of selected S₁ lines and recombined to form popn-918 = C918. 2911,...,2915 = recombinations of popns-911,...,-915. 0909-34 = C909-34. 0909-37 = C909-37. 2911-4,-12,-14,-50 = C911-4, C911-12, C911-14, & C911-50. 2890 = C890.

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TEST 1294. EVALUATION OF Y54 x B.m. GERMPLASM LINES, SALINAS, CA., 1994

12 entries x 8 replications, RCB
1-row plots, 21 ft. long

Planted: February 14, 1994
Harvested: September 27, 1994

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew %	Bolting %	RJAP %
US H11	rec'd 1/10/94	15758	47.50	16.58	0.0	148	8.2	0.0	84.0
Y954	Inc. Y854	15857	46.38	17.10	0.0	140	5.7	0.0	84.1
R380	RZM R280,R280Y	15660	47.51	16.52	0.0	145	6.8	0.0	84.5
R722	Inc. F$_2$(Y54 x B.m) (C50)	12591	39.55	15.91	0.0	142	6.9	24.3	81.3
R122R3	RZM R022R2	14207	45.65	15.59	0.0	146	8.0	9.4	80.8
R222R4	RZM R122R3	14530	47.45	15.34	0.0	148	8.4	17.0	81.3
R322R4	RZM R122R3 (GSY)	15562	49.05	15.86	0.4	147	8.0	4.1	82.0
R322R4 (%)	RZM R122R3 (%S)	13514	42.85	15.76	0.4	152	7.4	11.8	80.6
R022Y	Inc. R922Y	15360	46.65	16.48	0.0	143	6.5	0.0	81.4
R122Y2	BYV R922Y	16468	49.67	16.59	0.0	149	6.4	0.9	83.1
R322Y3	YR-ER-PMR R122Y2 (GSY)	15753	47.85	16.48	0.0	139	4.8	1.3	82.6
R322Y3 (%)	YR-ER-PMR R122Y2 (%S)	14930	43.99	17.00	0.0	137	6.3	0.8	82.7
Mean		15015.7	46.17	16.27	0.1	144.5	6.9	5.8	82.4
LSD (.05)		1141.3	3.73	0.56	0.5	10.7	0.8	3.9	1.2
C.V. (%)		7.6	8.12	3.45	697.7	7.4	11.7	67.6	1.5
F value		7.6**	4.59**	7.93**	0.9NS	1.4NS	14.8**	34.3**	9.8**

See Tests 2094, 3194, & 5694 for performance under virus yellows and rhizomania conditions.

C50 = F$_2$ (Y54 x B.maritima) = R722. R722 is the unselected source that is 50% sugarbeet (line Y54) and 50% from a B.maritima collection. To evaluate the potential genetic variability for disease resistance and productivity, recurrent phenotypic selection was made for resistance to rhizomania and resistance to virus yellows. This test was grown to evaluate the performance of the selected synthetics in the absence of severe disease.

[1] Y954 = C54 = line similar to sugarbeet line used to produce R722 (C50). Y954 was developed in the virus yellows and multiple disease resistance programs at Salinas and is susceptible to rhizomania. R380 = C54R$_z$. R22 lines identified with an R# suffix were selected for resistance to rhizomania and the last number gives the cycle of selection (see Test 2094). Y# synthetics were selected for resistance to virus yellows (see Test 5694).

TEST 2094. EVALUATION OF Y54 x B.m. GERMPLASM LINES UNDER VIRUS YELLOWS CONDITIONS, SALINAS, CA., 1994

12 entries x 8 replications, RCB
1-row plots, 21 ft. long

Planted: March 15, 1994
BYV/BWYV inoc: June 9, 1994
Harvested: October 4, 1994

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Virus Yellows %	Beets/100' No.	Powdery Mildew %	Bolters %	RJAP %
KWS 6770	High % S check	7744	25.75	15.02	7.4	149	6.3	0.0	80.3
Y954	Inc. Y854	7411	24.97	14.84	4.5	145	6.3	0.0	80.7
R380	RZM R280,R280Y	8539	29.42	14.51	4.5	140	6.7	0.0	80.4
R722	Inc. F₂(Y54 x B.m)(C50)	7921	29.20	13.54	4.0	155	6.8	13.6	79.6
R122R3	RZM R022R2	8137	30.05	13.53	4.8	145	8.3	4.9	78.9
R222R4	RZM R122R3	7745	29.35	13.21	4.9	154	8.6	6.3	77.9
R322R4	RZM R122R3 (GSY)	8209	30.00	13.70	4.7	150	8.4	2.3	77.8
R322R4 (%)	RZM R122R3 (%S)	7577	27.70	13.68	4.8	160	7.9	11.2	76.9
R022Y	Inc. R922Y	8865	31.05	14.30	4.5	143	6.6	0.4	78.9
R122Y2	BYV R922Y	8641	29.35	14.70	3.9	162	6.7	0.0	79.9
R322Y3	YR-ER-PMR R122Y2 (GSY)	8780	29.95	14.65	4.1	155	5.6	0.0	79.6
R322Y3 (%)	YR-ER-PMR R122Y2 (%S)	8925	29.38	15.19	3.6	148	6.6	0.4	79.2
Mean		8209.7	28.85	14.24	4.6	150.4	7.1	3.3	79.2
LSD (.05)		685.3	2.13	0.48	0.5	15.7	0.7	2.6	1.4
C.V. (%)		8.4	7.40	3.39	11.6	10.5	10.0	80.6	1.8
F value		4.8**	5.73**	15.57**	24.7**	1.5NS	15.3**	26.5**	5.1**

See Tests 1294, 3194, and 5694 for performance under nondiseased and rhizomania conditions. Test 2094 was grown under nonrhizomania conditions.

[1]See Test 1294 for general descriptions and Test 5694 for descriptions of rhizomania resistant selections. Y-suffix designates synthetics selected for resistance to virus yellows (BYV/BWYV). Y,Y2,Y3 = first, second, and third cycle synthetics. Virus yellows selections were made among individual, spaced plants that had been inoculated with VY and Erwinia and naturally infected with powdery mildew. Beets were selected on the basis of freedom from bolting, size, shape, and absence of sprangling, then reselected on the basis of sucrose concentration. For cycle 3, the selected roots were divided into two groups for seed production: (1) gross sugar yield; (2) %S. Thus for VY resistance selection, selection was based upon factors for productivity under VY and diseased conditions.

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TEST 5694. RHIZOMANIA EVALUATION OF LINES FROM R22, SALINAS, CA., 1994

16 entries x 8 replications, RCB (equalized)
1-row plots, 20 ft. long

Planted: May 23, 1994
Harvested: December 1, 1994

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolting %	RJAP %
US H11	L113401	2345	9.95	11.86	177	0.0	76.8
Rhizoguard	9/21/93	3921	15.01	13.11	191	0.0	78.9
Rizor	RZ3/1022 (1/21/93)	5069	17.53	14.45	204	0.0	76.5
Y139C7	RZM R039C6	5522	20.77	13.31	184	2.0	78.3
Y954	Inc. Y854 (C54)	3357	12.43	13.41	165	0.0	76.5
R380	RZM R280,Y	4917	17.53	13.96	184	0.0	79.4
R722	Inc. F2 (Y54 x B.m.)(C50)	3403	13.39	12.73	155	3.9	76.7
R122R3	RZM R022R2	5886	24.12	12.20	186	0.3	73.7
R222R4	RZM R122R3	5862	23.98	12.20	184	0.3	72.2
R322R4	RZM R122R3 (GSY)	5789	24.44	11.85	183	0.3	72.6
R322R4%	RZM R122R3 (%S)	5981	23.86	12.51	194	1.3	73.4
R322Y3%	YR-ER-PMR R122Y2 (%)	5117	18.32	14.05	168	0.0	76.0
R336	RZM 2243-#(C)	5118	20.14	12.74	146	0.0	73.4
R338H52	F92-790-15H39 x R38(C)	4374	17.17	12.76	166	0.0	75.5
R222R4H20	87-309H3 x RZM R122R3	5677	22.08	12.86	179	0.0	73.9
N303H15	2915aa x C603,C603-1	4419	19.71	11.20	174	0.0	73.9
Mean		4797.3	18.78	12.83	177.5	0.5	75.5
LSD (.05)		665.0	2.42	0.71	17.4	1.1	3.0
C.V. (%)		14.0	13.00	5.63	9.9	224.1	4.0
F value		20.6**	26.73**	11.78**	5.6**	7.0**	4.6**

See Tests 1294 and 2094 for performance under nondiseased and virus yellows conditions. Test 5694 was grown in Field C under severe rhizomania conditions. Also see Test 3194 for performance under rhizomania.

[1]See Test 1294 for general descriptions and Test 2094 for descriptions of virus yellows resistant selections. R-suffix designates synthetics selected for resistance to rhizomania. R3 and R4 = 3rd and 4th cycle synthetics. Selections for cycles R1,R2,R3, and R222R4 were based upon freedom from symptoms to rhizomania in 4 month old plants under rhizomania conditions. R322R4 and R322R4% were based upon mother root selections among 7 month old plants grown under rhizomania: R322R4 was selected for gross sugar yield; R322R4% was selected for % sucrose. Y139C7 = C39R with quantitative resistance to rhizomania. R380 = C54Rz. R336 = F2(C37 x R22). R38(C) = composite of sources of resistance in C37 background. N303H15 = hybrid with dual resistance to rhizomania (Rz) and cyst nematode from C603.

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TEST 2394. NON-RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB), SALINAS, CA., 1994

16 entries x 8 replications, RCB (equalized)
1-row plots, 31 ft. long

Planted: April 28, 1994
Harvested: October 6, 1994

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolting %	Powdery Mildew %	RJAP %
2394-1 IIRB entries								
US H11	113401	9874	32.82	15.05	236	0.0	7.9	82.1
R378H52	790-15H39 x R278	10571	34.69	15.25	223	0.0	6.6	82.6
Accord	IIRB, 1994	10605	33.17	16.00	201	0.0	5.7	83.6
Mondoro	IIRB, 1994	10331	34.08	15.14	218	0.0	6.1	83.2
Rizor	IIRB, 1994	10078	30.59	16.48	231	0.0	7.1	81.5
Stratos	IIRB, 1994	9911	30.69	16.16	220	0.0	5.0	82.9
Roxane	IIRB, 1994	10126	31.30	16.19	195	0.0	7.1	83.1
C48	IIRB, 1994	11367	36.38	15.63	220	0.0	7.2	83.2
Mean		10357.7	32.97	15.74	218.1	–	6.6	82.8
LSD (.05)		609.8	1.78	0.43	11.9	–	0.7	1.2
C. V. (%)		5.9	5.36	2.73	5.5	–	10.1	1.5
F value		5.3*	10.82**	12.92**	10.6**	–	15.7**	2.5*
2394-2 USDA entries								
KWS 6770	% sugar check	10831	32.08	16.92	214	0.0	6.0	83.6
Rhizoguard	rec'd 9/21/93	9211	29.51	15.63	220	0.0	7.8	81.9
R380H52	790-15H39 x R280	10926	36.01	15.18	213	0.0	6.1	82.0
R338H52	790-15H39 x R38(C)	10505	35.57	14.76	222	0.0	6.7	81.2
R322R4	RZM R122R3 (GSY)	9404	32.32	14.55	210	0.8	7.4	79.1
R332R2	RZM R232	9293	32.86	14.14	210	3.3	6.8	80.9
R337	RZM 2247-#(C)	8771	28.45	15.40	212	0.0	7.1	80.6
R338-1,-2,-3(C)	RZM R279 x R38(C)	9338	31.09	15.02	212	0.0	6.6	81.9
Mean		9785.0	32.24	15.20	214.1	0.5	7.0	81.4
LSD (.05)		512.3	1.56	0.36	13.9	0.4	0.5	1.0
C.V. (%)		5.2	4.81	2.33	6.4	83.1	7.4	1.3
F value		21.4**	23.18**	44.98**	0.9NS	60.4**	12.2**	13.0**

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TEST 2394. NON-RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB), SALINAS, CA., 1994

(cont.)

TEST 2394. NON-RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB), SALINAS, CA., 1994
16 entries x 8 replications, RCB (equalized); 2 subtests, 8 x 8, RCB (equalized)
1-row plots, 31 ft. long. ANOVA to compare means across sets.

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolting %	Powdery Mildew %	RJAP %
Mean		10071.4	32.60	15.47	216.1	0.3	6.7	82.1
LSD (.05)		627.9	1.87	0.40	13.2	0.3	0.7	1.1
C.V. (%)		6.3	5.79	2.58	6.2	121.7	10.1	1.4
F value		10.4**	12.06**	27.34**	4.6**	58.3**	10.5**	9.1**

See Tests 3494, 4394, and 5894 for performance under rhizomania conditions. Test 2394 showed no evidence of being infected with rhizomania. Although treated for powdery mildew control three times, by harvest powdery mildew was moderate in severity. By late in the season, some virus yellows occurred in the trial. There was no evidence of cyst nematode infestation.

[1]IIRB entries were Accord (susc. check), Monodoro, Rizor, Stratos, Roxane, and C48. Other entries were made by USDA: US H11 as rhizomania susceptible check; KWS 6770 as high % sugar susceptible check; R378H52 = USDA exp. hybrid with line similar to C46/2Rz as pollinator; Rhizoguard from Holly as resistant check; R380H52 = USDA Rz experimental hybrid; R38 = composite of sources of resistance in C37 background; R338-1,-2,-3(C) = C37Rz x sources of resistance in C37 background; R322R4 = 4th cycle selection for resistance to rhizomania from sugarbeet x B.maritima composite crosses; R322R2 = F₂BC₁(C37 x wild beet source from Italy) selected for resistance to rhizomania; and R337 = F₂BC₃(C37 x WB151 from Denmark) selected for resistance to rhizomania.

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TEST 2394. NON-RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB), SALINAS, CA., 1994

(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
2394-1 IIRB entries								
US H11	9345	285	94.6	529	154	1257	178	5371
R378H52	10000	289	94.6	571	162	1324	168	5476
Accord	10044	303	94.7	561	269	1331	144	5639
Mondoro	9779	287	94.6	552	226	1247	157	5404
Rizor	9518	311	94.5	560	136	1433	213	6085
Stratos	9373	306	94.6	538	287	1244	181	5835
Roxane	9531	305	94.1	594	225	1376	221	6328
C48	10782	297	94.8	585	196	1282	155	5367
Mean	9796.4	297.7	94.6	561.4	206.9	1311.7	177.3	5688.0
LSD (.05)	597.6	9.1	0.5	49.7	55.5	64.7	31.1	458.9
C.V. (%)	6.1	0.4	0.5	8.8	26.7	4.9	17.5	8.0
F value	5.2*	9.8**	1.4NS	1.6NS	7.8**	8.9**	6.3**	5.0**
2394-2 USDA entries								
KWS 6770	10361	324	95.7	470	176	1213	127	4857
Rhizoguard	8734	296	94.8	477	135	1286	177	5373
R380H52	10305	286	94.3	621	177	1398	173	5753
R338H52	9853	277	93.8	652	159	1448	203	6107
R322R4	8671	268	92.2	733	220	1625	286	7548
R332R2	8691	265	93.5	602	216	1455	177	6079
R337	8276	291	94.3	495	163	1416	179	5813
R338-1,-2,-3(C)	8780	283	94.0	558	145	1508	180	5991
Mean	9208.9	286.2	94.1	576.1	173.9	1418.8	187.8	5940.0
LSD (.05)	501.3	7.9	0.6	56.5	43.4	88.0	28.5	514.3
C.V. (%)	5.4	2.7	0.6	9.8	24.9	6.2	15.1	8.6
F value	22.0**	45.1**	23.8**	22.1**	4.1**	16.9**	20.0**	18.2**

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(cont.)

TEST 2394. NON-RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB), SALINAS, CA., 1994
16 entries x 8 replications, RCB (equalized); 2 subtests, 8 x 8, RCB (equalized)
1-row plots, 31 ft. long. ANOVA to compare means across sets.

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
Mean	9502.7	291.9	94.3	568.7	190.4	1365.2	182.6	5814.0
LSD (.05)	606.0	8.5	0.6	58.0	50.7	80.3	30.1	489.1
C.V. (%)	6.4	2.9	0.6	10.3	26.9	5.9	16.7	8.5
F value	11.1**	26.8**	14.7**	10.2**	6.5**	15.5**	11.4**	11.7**

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TEST 3494. RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB), SALINAS, CA., 1994

Planted: April 20, 1994
Harvested: October 31, 1994

16 entries x 8 replications, RCB
1-row plots, 20 ft. long

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %
3494-1 IIRB entries						
US H11	113401	3689	12.55	14.66	213	85.9
R378H52	790-15H39 x R278	7576	23.42	16.15	209	83.4
Accord	IIRB, 1994	3633	12.02	15.18	178	87.8
Mondoro	IIRB, 1994	5895	18.69	15.73	184	85.0
Rizor	IIRB, 1994	7403	22.10	16.75	208	81.0
Stratos	IIRB, 1994	6077	18.32	16.61	192	84.4
Roxane	IIRB, 1994	4135	13.86	14.89	188	83.6
C48	IIRB, 1994	7234	22.21	16.29	181	83.6
3494-2 USDA entries						
KWS 6770	% sugar check	4145	12.70	16.30	189	82.9
Rhizoguard	rec'd 9/21/93	5782	17.69	16.36	213	84.4
R380H52	790-15H39 x R280	6917	21.05	16.52	196	84.4
R338H52	790-15H39 x R38(C)	6252	19.95	15.68	211	83.5
R322R4	RZM R122R3 (GSY)	9464	30.56	15.51	191	82.2
R332R2	RZM R232	6541	21.00	15.66	213	85.3
R338	RZM 2247-#(C)	5168	16.28	15.94	201	81.9
R338-1,-2,-3(C)	RZM R279 x R38(C)	5661	17.64	16.15	207	83.5
Mean		5973.2	18.75	15.90	198.2	83.9
LSD (.05)		981.2	3.02	0.77	22.3	2.9
C.V. (%)		16.6	16.26	4.90	11.3	3.5
F value		20.6**	20.01**	4.97**	2.4**	2.5**

Notes: Rhizomania was very severe. This was the third sugarbeet crop in rhizomania tests in five years. In additions, cyst nematode was moderate. Root aphids were mild. Stands were good and the usual problem with seedling loss (Aphanomyces) was not experienced. Nitrogen was applied as if a normal crop, but canopy suggested nitrogen deficiency, probably due to an impaired root system not being able to forage for nitrogen, other nutrients, and water efficiently. Even under moist and cool conditions, plants wilted most afternoons. There was no loss of plants due to root rots.

See Test 2394 for performance without rhizomania and Test 4394 & 5894 for performance with rhizomania.

[1]See Test 2394 for variety description.

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TEST 3494. RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB), SALINAS, CA., 1994

(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
94-1 IIRB entries								
US H11	3479	277	94.3	210	568	1195	56	5504
R378H52	7228	308	95.4	348	367	1083	97	4912
Accord	3404	284	93.7	229	767	1250	56	6338
Mondoro	5606	299	95.0	290	564	997	76	5190
Rizor	6988	316	94.4	415	388	1288	171	6198
Stratos	5741	314	94.5	336	702	989	121	6074
Roxane	3871	279	93.5	264	733	1261	70	6381
C48	6860	309	94.8	373	534	1085	108	5610
94-2 USDA entries								
6770	3969	312	95.7	176	485	990	51	4657
Rhizoguard	5518	312	95.5	263	351	1120	95	4928
R380H52	6570	314	95.1	346	400	1168	107	5338
R338H52	5942	298	95.1	310	381	1177	92	5147
R322R4	8757	288	92.7	707	403	1468	258	7533
R332R2	6239	299	95.4	302	440	1037	71	4805
R338	4925	304	95.4	243	384	1110	84	4912
R338-1,-2,-3(C)	5393	308	95.3	268	319	1211	89	4987
Mean	5655.7	301.4	94.7	317.4	486.6	1151.7	100.0	5532.1
LSD (.05)	920.5	15.9	0.8	86.3	139.0	121.3	30.4	714.9
C.V. (%)	16.4	5.3	0.8	27.4	28.8	10.6	30.7	13.0
F value	20.5**	5.3**	9.3**	15.5**	8.4**	8.9**	22.5**	9.4**

TEST 4394. YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA, IIRB, SALINAS, CA., 1994

Planted: May 10, 1994
Harvested: October 20, 1994

16 entries x 8 replications, RCB (equalized)
1-row plots, 20 ft. long
2 subtests; 8 entries x 8 reps., RCB (equalized).

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Powdery Mildew %	RJAP %
4394-1 IIRB entries							
US H11	113401	6020	22.84	13.23	168	6.8	84.0
R378H52	790-15H39 x R278	9362	33.02	14.18	164	3.2	84.3
Accord	IIRB, 1994	6082	22.56	13.49	147	3.0	84.9
Mondoro	IIRB, 1994	8329	29.08	14.36	144	4.9	84.1
Rizor	IIRB, 1994	9029	28.14	16.04	161	6.3	82.4
Stratos	IIRB, 1994	9274	30.02	15.45	156	3.3	83.8
Roxane	IIRB, 1994	7365	27.01	13.69	146	5.6	84.1
C48	IIRB, 1994	8944	30.29	14.78	165	5.8	83.5
Mean		8050.7	27.87	14.40	156.3	4.8	83.9
LSD (.05)		539.4	1.67	0.42	9.2	0.9	1.4
C.V. (%)		6.7	5.96	2.87	5.9	17.6	1.6
F value		53.6**	38.42**	44.96**	8.3**	25.0**	2.4NS
4394-2 USDA entries							
KWS 6770	% sugar check	7459	24.28	15.38	157	5.8	86.2
Rhizoguard	rec'd 9/21/93	7097	24.63	14.47	166	6.4	84.6
R380H52	790-15H39 x R280	9105	31.13	14.64	168	4.8	83.1
R338H52	790-15H39 x R38(C)	8417	30.03	14.02	164	6.3	84.1
R322R4	RZM R122R3 (GSY)	8165	28.98	14.10	170	6.2	80.3
R332R2	RZM R232	8249	30.61	13.48	160	6.1	83.6
R337	RZM 2247-#(C)	7620	25.57	14.96	164	5.8	83.4
R338-1,-2,-3(C)	RZM R279 x R38(C)	7695	25.68	15.01	163	6.3	83.6
Mean		7975.8	27.61	14.51	164.0	6.0	83.6
LSD (.05)		605.0	1.94	0.37	12.0	0.6	0.7
C.V. (%)		7.6	6.98	2.53	7.3	9.9	0.8
F value		8.9**	17.55**	22.78**	1.0NS	6.2**	53.4**

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(cont.)

| Variety[1] | Description | Acre Yield | | Sucrose | Beets/ 100' | Powdery Mildew | RJAP |
		Sugar Lbs	Beets Tons	%	No.	%	%

TEST 4394. YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA, IIRB, SALINAS, CA., 1994
16 entries x 8 replications, RCB (equalized). ANOVA to compare means across sets of entries.

Mean		8013.2	27.74	14.45	160.1	5.4	83.8
LSD (.05)		613.2	1.93	0.43	11.9	0.8	1.5
C.V. (%)		7.7	7.03	3.03	7.5	14.5	1.8
F value		22.8**	21.08**	26.27**	3.6**	19.8**	5.5**

<u>Notes:</u> Field in nonrhizomnia tests in 1991. In August 1993, rhizomania infested soil was broadcast over area and disced in, area was then bedded up, planted without subsequent thinning to susceptible sugarbeet, and frequently irrigated for two months. About Nov. 1, 1994, sugarbeets were disced under. In the spring of 1994, area was prepared for sugarbeet tests. In October 1993, plant samples were positive (ELISA) for BNYVV. In February 1994, soil samples proved to be uniformly positive for BNYVV. May 1994 planted rhizomania trials established and grew without problems. Field uniformity was very good and sugarbeet crop looked nearly normal for color and vigor. At harvest, rhizomania symptoms were moderate. Cyst nematode and root aphid infestations were mild. No root rot occurred.

See Test 2394 for performance without known rhizomania and Tests 3494 and 4394 for performance under severe rhizomania.

[1]See Test 2394 for variety descriptions.

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TEST 4394. YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA, IIRB, SALINAS, CA., 1994

(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
4394-1 IIRB entries								
US H11	5513	243	91.7	507	520	1533	172	7290
R378H52	8504	258	90.8	858	499	1706	279	8665
Accord	5550	246	91.2	533	750	1545	140	7816
Mondoro	7608	263	91.4	721	577	1543	243	8186
Rizor	8308	295	92.0	721	319	1665	344	8543
Stratos	8506	284	91.7	768	619	1448	283	8478
Roxane	6655	248	90.4	709	804	1610	193	8672
C48	8123	269	90.8	821	534	1606	328	9002
Mean	7346.0	263.1	91.3	704.7	577.6	1582.0	247.9	8331.5
LSD (.05)	492.1	8.4	0.7	71.3	104.4	102.8	41.2	560.7
C.V. (%)	6.7	3.2	0.7	10.1	18.0	6.5	16.6	6.7
F value	54.1	39.8**	5.4*	25.1**	17.0**	5.1**	26.0**	7.8**
4394-2 USDA entries								
KWS 6770	7001	288	93.9	458	431	1328	149	6246
Rhizoguard	6561	268	92.5	537	462	1441	213	7244
R380H52	8291	267	91.1	814	445	1727	298	8700
R338H52	7677	256	91.2	740	399	1692	269	8178
R322R4	7234	250	88.5	931	463	2006	427	10690
R332R2	7450	243	90.3	799	484	1758	272	8675
R337	6936	273	91.1	684	366	1772	332	8859
R338-1,-2,-3(C)	8242	276	91.7	641	298	1818	280	8242
Mean	7275.4	265.0	91.3	700.4	418.3	1692.6	279.9	8354.1
LSD (.05)	564.6	8.5	0.9	89.2	97.1	143.2	45.7	777.8
C.V. (%)	7.7	3.2	1.0	12.7	23.1	8.4	16.3	9.3
F value	7.2**	23.9**	22.6**	24.2**	3.3**	18.2**	25.6**	22.2**

TEST 4394. YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA, IIRB, SALINAS, CA., 1994

(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value

TEST 4394. YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA, IIRB, SALINAS, CA., 1994
16 entries x 8 replications, RCB (equalized). ANOVA to compare means across sets of entries.

	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
Mean	7310.7	264.1	91.3	702.6	498.0	1637.3	263.9	8342.8
LSD (.05)	565.7	9.4	0.9	88.9	111.9	129.4	48.0	756.6
C.V. (%)	7.8	3.6	1.0	12.8	22.7	8.0	18.4	9.2
F value	21.8*	23.3**	12.1**	18.3**	12.1**	13.1**	20.1**	12.6**

TEST 5894. YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB), SALINAS, CA., 1994

Planted: May 23, 1994
Harvested: November 28, 1994

16 entries x 8 replications, RCB (equalized)
1-row plots, 20 ft. long

Variety[1]	Description	Acre yield Sugar Lbs	Acre yield Beets Tons	Sucrose %	Beets/100' No.	Bolting %	RJAP %
5894-1 IIRB entries							
US H11	L113401	2442	12.16	10.00	184	0.0	72.0
R378H52	790-15H39 x R278	5336	21.21	12.59	190	0.0	76.1
Accord	IIRB, 1994	2608	13.57	9.54	145	0.0	72.1
Monodoro	IIRB, 1994	4582	20.25	11.32	178	0.0	75.4
Rizor	IIRB, 1994	5714	20.71	13.81	221	0.0	74.1
Stratos	IIRB, 1994	4081	16.48	12.31	199	0.0	75.0
Roxan	IIRB, 1994	3216	15.23	10.46	151	0.0	71.7
C48	IIRB, 1994	5193	20.63	12.66	166	0.0	77.5
Mean		4146.4	17.53	11.59	179.2	—	74.2
LSD (.05)		647.0	2.52	0.76	21.0	—	2.7
C.V. (%)		15.5	14.33	6.52	11.7	—	3.6
F value		31.2**	16.60**	31.31**	11.5**	—	5.1**
5894-2 USDA entries							
KWS 6770	% sugar check	2642	11.23	11.69	183	0.0	76.3
Rhizoguard	rec'd 9/21/93	4123	16.86	12.23	197	0.0	75.6
R380H52	790-15H39 x R280	5551	21.93	12.64	192	0.0	74.5
R338H52	790-15H39 x R38(C)	4578	19.28	11.89	183	0.0	73.7
R322R4	RZM R122R3 (GSY)	6521	27.33	11.98	199	0.3	72.3
R332R2	RZM R232	4211	19.61	10.74	175	0.4	72.4
R337	RZM 2247-#(C)	4056	15.35	13.19	188	0.0	74.8
R338-1,-2,-3(C)	RZM R279 x R38(C)	3832	15.08	12.68	171	0.0	73.0
Mean		4439.2	18.33	12.13	185.8	0.1	74.1
LSD (.05)		572.6	2.15	0.67	20.5	0.5	3.4
C.V. (%)		12.8	11.66	5.53	11.0	555.1	4.6
F value		33.4**	42.13**	9.85**	2.0NS	0.9NS	1.5NS

TEST 5894. YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB), SALINAS, CA., 1994

16 entries x 8 replications, RCB (equalized); 2 subtests each: 8 x 8 , RCB (equalized)
1-row plots, 20 ft. long. ANOVA to compare means across sets.

Variety[1]	Description	Acre Yield			Beets/		
		Sugar	Beets	Sucrose	100'	Bolting	RJAP
		Lbs	Tons	%	No.	%	%
Mean		4292.8	17.93	11.86	182.5	0.0	74.1
LSD (.05)		614.2	2.40	0.81	22.4	0.3	3.1
C.V. (%)		14.5	13.55	6.88	12.4	801.5	4.2
F value		29.3**	23.73**	16.60**	5.5**	0.9NS	2.6**

See Test 2394 for performance without rhizomania and Tests 3494 & 4394 for performance with rhizomania.

[1]See Test 2394 for variety descriptions.

Notes: Test 3494, 4394, & 2394 were grown at Spence Field. Test 5894 was grown in Field C at the Research Station. This was the third consecutive year under rhizomania conditions. Rhizomania was severe. Infection with powdery mildew and virus yellows was moderate. Cercospora leaf spot infection was moderate. Cyst nematodes occurred.

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DAVIS 1994-1. EVALUATION OF HYBRIDS FOR REACTION TO VIRUS YELLOWS, DAVIS, CA., 1994

Planted: May 10, 1994
Harvested: October 21, 1994

12 varieties x 2 virus trtmts x 6 reps (Split-plot)
1-row plots, 29 ft. long, 30" wide.

Variety	Description	Acre Yield[1] Sugar lbs	Acre Yield[1] Beets tons	Acre Yield[1] Sucrose %	Acre Yield[2] Sugar lbs	Acre Yield[2] Beets tons	Acre Yield[2] Sucrose %	Acre Yield[3] Sugar lbs	Acre Yield[3] Beets tons	Acre Yield[3] Sucrose %
Commercial Hybrids										
4454	Betaseed 4454.2634 (2/94)	7965	27.37	14.46	5608	19.95	14.06	10321	34.80	14.86
SS-VY1	Speckels (3/2/94)	6375	21.65	14.73	4181	14.29	14.68	8569	29.02	14.77
HH95	Holly (5/5/94)	7594	25.65	14.84	5687	19.43	14.77	9500	31.87	14.91
6027	Hilleshog-MH (5/5/94)	6910	23.71	14.64	5232	17.95	14.73	8587	29.47	14.55
Susceptible check										
6770	VY susc.,high % S check (2/94)	6559	21.05	15.49	4401	14.59	15.10	8718	27.51	15.88
USDA experimental hybrids										
R384H50	F92-790-15CMS x R176-43;-89-#	7526	25.53	14.73	5955	20.45	14.61	9098	30.61	14.86
R384H51	F92-790-15H26 x R176-43;-89-#	7109	24.03	14.78	5491	19.11	14.48	8726	28.94	15.08
R384H52	F92-790-15H39 x R176-43;-89-#	7485	25.90	14.39	5103	17.96	14.19	9866	33.84	14.58
R380H46	F92-790- 6CMS x R280,Y	7335	25.40	14.38	5343	19.17	14.02	9327	31.63	14.74
R380H50	F92-790-15CMS x R280,Y	7569	25.74	14.68	5909	20.33	14.57	9229	31.16	14.80
R380H54	F92-790-54CMS x R280,Y	7392	25.52	14.42	5436	19.15	14.18	9347	31.90	14.66
3918H50	F92-790-15CMS x 1913-#,1915-#	6845	23.77	14.36	5036	17.93	14.11	8655	29.61	14.62
Mean		7221.9	24.61	14.66	5281.8	18.36	14.46	9161.9	30.86	14.86
LSD (.05)		574.1	1.99	0.41	812.0	2.81	0.59	812.0	2.81	0.59
C.V. (%)		9.8	9.99	3.49	9.8	9.99	3.49	9.8	9.99	3.49
F value - variety		5.2**	6.72**	4.50**	391.5**	230.93**	6.15*	391.5**	230.93**	6.15*
F value - virus		**	**	*						
F value - variety x virus		*	NS	NS						

[1] Variety means over both virus treatments analyzed as split-plot.
[2] Variety means for inoculated treatment. BYV/BWYV inoculated June 15, 1994.
[3] Variety means for noninoculated treatment.

Notes:
Inoculated vs. noninoculated to evaluate reaction and performance under virus yellows conditions. Commercial or near-commercial experimental hybrids. R176-43;-89-# = C76-43 and C76-89 combined into one pollinator. R280,Y = combined versions of R280 (rhizomania resistant selection) and R280Y (rhizomania and VY resistant selection). 1913-#,1915-# = combined S[1] lines similar to C918.

DAVIS 1994-1. EVALUATION OF HYBRIDS FOR REACTION TO VIRUS YELLOWS, DAVIS, CA., 1994
(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value	Nitrate brei
Commercial Hybrids									
4454	6297	227	78.5	1668	274	1251	1745	20661	97
SS-VY1	5013	230	78.1	1362	272	1168	1862	21559	77
HH95	6308	247	83.1	1286	304	1169	1321	16536	87
6027	5491	233	79.7	1419	270	1186	1674	19818	68
Susceptible check									
6770	5495	260	83.8	1064	296	1121	1348	16647	80
USDA experimental hybrids									
R384H50	6174	241	81.9	1352	260	1113	1481	17763	80
R384H51	5751	239	80.9	1358	305	1137	1569	18813	86
R384H52	6036	232	80.6	1449	277	1144	1554	18588	88
R380H46	5924	232	80.6	1411	273	1254	1524	18568	75
R380H50	6202	241	81.9	1367	236	1228	1452	17691	66
R380H54	5995	233	80.7	1396	260	1121	1552	18455	75
3918H50	5444	228	79.4	1401	327	1123	1661	19735	74
Mean	5844.2	237.0	80.8	1377.7	279.4	1168.0	1562.0	18736.3	79.3
LSD (.05)	527.9	12.4	2.8	237.5	67.7	125.7	267.1	2560.0	13.5
C.V. (%)	11.2	6.5	4.2	21.3	30.0	13.3	21.1	16.9	21.1
F value - var	4.7**	4.5**	1.2NS	2.5**	1.0NS	1.3NS	2.7**	2.7**	3.4**
Non-inoc mean	4259.7	233.0	80.5	1022.1	290.4	1196.3	1548.1	18714.3	77.7
Inoc mean	7428.7	240.9	81.0	1733.2	268.4	1139.7	1575.8	18758.3	80.9
F value - vir	**	*	NS	**	NS	NS	NS	NS	NS
F value - v x v	*	NS	NS	NS	NS	NS	NS	NS	NS

Note: Variety means over both virus treatments analyzed as split-plot (12 var x 12 reps).
Grown by Dr. S. Kaffka and G. Peterson, U.C. Davis. Sugar and impurity analyses by Spreckels Sugar, Woodland, CA.

DAVIS 1994-2. EVALUATION OF POLLINATOR LINES FOR PERFORMANCE UNDER VIRUS YELLOWS,
DAVIS, CA., 1994

Planted: May 10, 1994
Harvested: October 21, 1994
BYV/BWYV inoc: June 15, 1994

12 varieties x 6 reps, RCB
1-row plots, 29' long, 30" wide

| Variety | Description | Acre Yield | | Sucrose | Clean Beets |
		Sugar lbs	Beets tons	%	%
R376H50	F92-790-15CMS x RZM R276,Y	5003	18.63	13.48	93.2
R378H50	F92-790-15CMS x RZM R278,Y	4839	17.58	13.82	92.3
R380H50	F92-790-15CMS x RZM R280,Y	4885	17.59	13.92	91.6
R384H50	F92-790-15CMS x R176-43;-89-#	4621	16.89	13.70	91.9
3915H50	F92-790-15CMS x 2911,...,2915	4053	14.93	13.62	91.8
3918H50	F92-790-15CMS x 1913-#,1915-#	3731	13.66	13.70	91.3
3909-34H50	F92-790-15CMS x RZM 0909-34	4151	15.39	13.51	93.7
3909-37H50	F92-790-15CMS x RZM 0909-37	4397	16.69	13.26	92.4
3911- 4H50	F92-790-15CMS x 2911- 4	3844	13.87	13.82	92.8
3911-12H50	F92-790-15CMS x 2911-12	4139	15.26	13.63	92.1
3911-14H50	F92-790-15CMS x 2911-14	3818	14.08	13.56	92.3
3911-50H50	F92-790-15CMS x 2911-50	4111	15.47	13.34	93.4
Mean		4299.3	15.84	13.61	92.4
LSD (.05)		676.2	2.53	0.46	1.4
C.V. (%)		13.6	13.81	2.91	1.3
F value		3.4**	3.30**	1.49NS	2.3*

Notes:
Test uniformly inoculated with BYV/BWYV to evaluate performance and adaptation under severe virus yellows
conditions at Davis. F90-790-15CMS = C790-15CMS. Pollinators have history of selection for VY and
rhizomania resistance. R276,Y; R278,Y; R280,Y = rhizomania resistant versions of C31/6, C46/2, C54,
respectively. R176-43;-89-# = C76-43 and C76-89 combined into one pollinator. 2911,...,2915 = combined
versions of MM,S^f,A:aa, Rz populations. 1913-#, 1915-# = combined S_l lines to produce population = C918
released in 1993. 0909-34,...,2911-50 = pollinators similar to C909-34, C909-37, C911-4, C911-12, C911-14,
and C911-50 released in 1993.

DAVIS 1994-2. EVALUATION OF POLLINATOR LINES FOR PERFORMANCE UNDER VIRUS YELLOWS, DAVIS, CA., 1994

(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value	Nitrate brei
R376H50	4102	221	82.0	902	342	1321	1221	16105	95
R378H50	3896	223	80.6	942	323	1384	1393	17826	85
R380H50	3982	226	81.3	903	292	1335	1363	17309	82
R384H50	3775	224	81.8	846	297	1300	1305	16691	102
3915H50	3296	221	81.2	757	320	1426	1307	17105	101
3918H50	3009	220	80.5	722	279	1416	1388	17703	84
3909-34H50	3313	215	79.6	838	304	1293	1483	18384	99
3909-37H50	3591	215	81.2	806	324	1331	1281	16630	98
3911- 4H50	3088	222	80.3	756	235	1448	1446	18177	96
3911-12H50	3298	217	79.7	840	271	1488	1452	18464	76
3911-14H50	3183	227	83.6	635	271	1364	1098	14794	75
3911-50H50	3302	213	80.0	809	274	1367	1412	17787	95
Mean	3486.2	220.5	81.0	813.1	294.3	1372.8	1345.9	17247.8	90.7
LSD (.05)	608.7	11.9	2.9	142.9	70.3	83.0	276.6	2633.4	24.9
C.V. (%)	15.1	4.7	3.1	15.2	20.6	5.2	17.8	13.2	23.7
F value	3.0**	1.1NS	1.2NS	2.9**	1.5NS	4.4**	1.3NS	1.3NS	1.2NS

Notes: Test grown by Dr. Steve Kaffka and G. Peterson, U.C., Davis. Sugar and impurity analysis by Spreckels Sugar. A severe field gradient occurred in this field plot area that reduced yields and increased variability.

A93

DAVIS 1994-3. EVALUATION OF EXPERIMENTAL HYBRIDS AND LINES UNDER VIRUS YELLOWS, DAVIS, CA., 1994

12 varieties x 6 reps, RCB
1-row plots, 29" long, 30" wide

Planted: May 10, 1994
Harvested: October 21, 1994
BYV/BWYV inoc: June 15, 1994

Variety	Description	Acre Yield Sugar lbs	Acre Yield Beets tons	Sucrose %	Clean Beets %
Experimental Hybrids					
R384H20	87-309H3 x R176-43-;-89-#	4480	16.92	13.27	92.5
R376-43-14H20	87-309H3 x R176-43-14	4537	17.60	12.91	92.3
R376-43-CH20	87-309H3 x R176-43-C	5126	18.94	13.53	91.9
R376-89-5H20	87-309H3 x R176-89-5	4393	15.96	13.78	92.9
R376-89-18H20	87-309H3 x R176-89-18	5150	19.36	13.30	93.7
R376-89-CH20	87-309H3 x R176-89-C	4975	18.30	13.59	92.1
3913-70H20	87-309H3 x 1913-70(S_1)	5007	19.22	13.01	92.7
3913-71H20	87-309H3 x 1913-71(S_1)	4617	17.93	12.90	91.3
R338H52	F92-790-15H39 x R38(C)	4801	18.59	12.92	92.5
Open-pollinated lines					
R322Y3%	YR-ER-PMR R122Y2 (%S)	5359	19.46	13.78	90.9
R322R4	RZM R122R3 (GSY)	3440	13.97	12.31	89.6
R384	Inc. R176-43-#; R176-89-#	5107	18.98	13.47	93.8
Mean		4749.3	17.94	13.23	92.18
LSD (.05)		522.0	1.90	0.38	1.90
C.V. (%)		9.5	9.14	2.51	1.78
F value		7.8**	5.99**	10.42**	3.07**

Notes:
Test uniformly inoculated with BYV/BWYV to evaluate performance and adaptation under virus yellows conditions at Davis. 87-309H3 = C562CMS x C309. R176-43-C = C76-43. R176-89-C = C76-89. R176-43-# and R176-89-# = selected full sib families. 1913-#S_1 = selected S_1 progenies from popn-913. R38(C) = composite of sources of resistance to rhizomania in C37 background. Y322Y3% = increase of mother roots of third cycle selection for resistance to virus yellows based upon % sugar from a sugarbeet x B.m. population. R322R4 = increase of mother roots of fourth cycle selection for resistance to rhizomania based upon gross sugar yield from a sugarbeet x B.m. population. R384 = combined increase of C76-43 & C76-89.

Test grown by Dr. Steve Kaffka and G. Peterson, U.C., Davis. Sugar and impurity analyses by Spreckels Sugar, Woodland, CA.

A94

DAVIS 1994-3. EVALUATION OF EXPERIMENTAL HYBRIDS AND LINES UNDER VIRUS YELLOWS, DAVIS, CA., 1994

(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value	Nitrate brei
Experimental hybrids									
R384H2O	3524	209	78.6	956	283	1303	1525	18739	84
R376-43-14H2O	3615	207	80.0	921	389	1318	1315	17148	120
R376-43-CH2O	4078	216	79.6	1048	299	1311	1480	18385	88
R376-89-5H2O	3487	219	79.4	906	243	1353	1544	18898	85
R376-89-18H2O	4102	212	79.6	1048	263	1427	1422	17997	91
R376-89-CH2O	3930	215	79.0	1044	320	1314	1533	18968	93
3913-70H2O	3908	203	78.2	1099	318	1400	1512	18974	90
3913-71H2O	3339	188	72.7	1278	308	1434	1977	23443	107
R338H52	3610	195	75.3	1191	262	1460	1747	21163	94
Open-pollinated lines									
R322Y3%	4150	214	77.7	1209	267	1487	1663	20452	69
R322R4	2696	193	78.3	745	314	1462	1366	17728	116
R384	4263	225	83.6	844	333	1350	1071	14719	95
Mean	3725.3	208.0	78.5	1024.0	299.9	1384.9	1512.9	18884.4	94.2
LSD (.05)	463.0	15.0	4.6	248.9	57.0	96.9	398.7	3797.1	15.0
C.V. (%)	10.7	6.3	5.0	21.0	16.4	6.0	22.8	17.4	13.8
F value	7.3**	4.6**	2.7**	3.2**	3.9**	3.9**	2.6*	2.6**	7.0**

A95

TEST 1194. PERFORMANCE OF GERMPLASM LINES WITH C37 BACKGROUND, SALINAS, CA., 1994

Planted: February 14, 1994
Harvested: September 28, 1994

12 entries x 8 replications, RCB
1-row plots, 21 ft. long

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/100' No.	Powdery Mildew %	Bolting %	RJAP %
U86-37	Inc. C37 (86443)	13777	42.15	16.34	0.0	145	8.4	0.0	84.4
R379	RZM R279, R2,(Rz),C79-1	14135	44.35	15.94	0.0	144	8.0	3.6	84.9
R336	RZM 2243-#(C),(R22),C79-8	16136	51.85	15.56	0.0	149	8.6	0.0	81.9
R332	RZM 2201-#(C),(R04),C79-5	15042	48.65	15.44	0.4	143	7.6	12.9	84.6
R332R2	RZM R232,(R04),C79-5	15033	49.89	15.07	0.0	142	7.7	18.5	84.3
R328	RZM 2202-#(C),(PI07),C79-4	14257	45.17	15.79	0.5	144	8.6	0.0	83.7
R334	RZM 2245-#(C),(R05),C79-6	15816	46.25	17.11	0.0	145	7.3	0.0	83.9
R337	RZM 2247-#(C),(WB 151),C79-9	15210	45.53	16.71	0.0	146	7.4	1.6	82.9
R335	RZM 2242-#(C),(Rima),C79-7	16422	48.10	17.07	0.4	146	7.6	0.0	83.3
R338-1,2,3	RZM R279R2,I,Y x R38	15657	48.27	16.20	0.4	145	8.1	0.8	83.5
R338-13	RZM 2243-#(C) x R38	15591	49.71	15.68	0.0	137	8.6	0.9	82.7
US H11	rec'd 1/10/94	16764	50.55	16.57	0.0	146	8.6	0.0	84.8
Mean		15320.0	47.54	16.12	0.1	144.4	8.0	3.2	83.7
LSD (.05)		1181.6	3.56	0.36	0.7	9.8	0.5	3.6	1.1
C.V. (%)		7.8	7.52	2.23	490.3	6.8	6.0	112.4	1.3
F value		4.9**	5.16**	26.36**	0.7NS	0.7NS	9.1**	22.9**	5.5**

See Tests 1594, 3194, 4894, 5594, and 5994. Test 1194 was grown under nondiseased conditions.

In 1994, C79-1 through C79-11 were released. These 11 lines have a C37 background with different sources of resistance to rhizomania. The lines evaluated in the above tests involve some of these sources of resistance but usually with fewer backcrosses to C37 than the released material. Some of the released sources were not available for field tests in 1994. Listed to the right side under the column for "Description" are the salinas codes for the breeding line source of resistance, and what the assigned release number is for the released version. See the release statement for a more complete description of the sources of resistance. R38 = composite of versions of C37Rz x R38. R338-13 = (C37 x R22 source) x R38. R2 means 2nd cycle of selection for resistance to rhizomania and line tested is F_3. Most other lines are F_2's generated by increasing rhizomania resistant selections within F_1BC_n lines. C37 is a narrowly bred, O.P. line with moderately low vigor. Some increase in yield is probably due to the increased genetic diversity within the backcrossed lines.

A96

TEST 1594. PERFORMANCE OF GERMPLASM LINES WITH C37 BACKGROUND UNDER VIRUS YELLOWS CONDITIONS, SALINAS, CA., 1994

12 entries x 8 reps., RCB
1-row plots, 21 ft. long

Planted: March 14, 1994
BYV/BWYV Inoc: June 9, 1994
Harvested: October 4, 1994

| Variety | Description | Acre Yield | | Sucrose | Virus Yellows | Beets/ 100' | Powdery Mildew | Bolting | RJAP |
		Sugar Lbs	Beets Tons	%	%	No.	%	%	%
U86-37	Inc. C37 (86443)	7558	26.92	14.04	3.5	138	8.9	0.0	80.3
R379	RZM R279,R2,(Rz),C79-1	6723	24.10	13.93	4.8	132	8.9	0.0	80.3
R336	RZM 2243-#(C),(R22),C79-8	7731	28.32	13.64	5.0	131	8.7	0.0	78.2
R332	RZM 2201-#(C),(R04),C79-5	7141	26.85	13.31	4.1	137	8.2	5.1	79.4
R332R2	RZM R232,(R04),C79-5	7953	30.20	13.13	4.4	126	8.3	13.4	82.2
R328	RZM 2202-#(C),(PIO7),C79-4	7139	25.95	13.76	4.3	137	8.9	0.0	79.7
R334	RZM 2245-#(C),(R05),C79-6	7532	26.35	14.29	6.0	132	8.4	0.0	79.1
R337	RZM 2247-#(C),(WB151),C79-9	7067	25.32	13.96	4.9	131	8.2	0.4	79.4
R335	RZM 2242-#(C),(Rima),C79-7	8544	29.49	14.48	5.6	135	8.4	0.0	79.2
R338-1,2,3	RZM R279R2,I,Y x R38	7452	26.46	14.07	5.3	124	8.6	0.4	80.2
R338-13	RZM 2243-#(C) x R38	7564	27.94	13.56	5.2	123	8.8	0.0	78.5
KWS 6770	High % Sugar check	7177	24.53	14.63	8.1	112	6.8	0.4	81.4
Mean		7465.0	26.87	13.90	5.1	129.9	8.4	1.7	79.8
LSD (.05)		612.9	2.08	0.44	0.7	15.7	0.4	2.3	1.6
C.V. (%)		8.3	7.76	3.15	12.6	12.1	5.3	141.2	2.0
F value		4.8**	6.37**	8.41**	26.4**	1.8NS	13.7**	23.2**	3.9**

See Test 1194 for performance under nondiseased conditions and more detailed descriptions of lines evaluated.
See Tests 3194, 4894, 5594, and 5994 for performance of sources of resistance under rhizomania conditions.

TEST 3194. RHIZOMANIA EVALUATION OF GERMPLASM LINES WITH DIFFERENT SOURCES OF RESISTANCE, SALINAS, CA., 1994

Planted: April 20, 1994
Harvested: October 31, 1994

16 entries x 8 replications, RCB
1-row plots, 20 ft. long

Variety	Description	Acre yield Sugar Lbs	Acre yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	Bolting %	RJAP %
Rizor	RZ3/1022 (1993)	6395	18.43	17.38	189	0.0	0.6	81.1
U86-37	Inc. C37	3448	11.29	15.25	191	0.0	0.4	82.5
R328	RZM 2202-#(C),(PI07),C79-4	5375	16.43	16.27	202	0.0	0.6	82.7
R332	RZM 2202-#(C),(R04),C79-5	5331	17.06	15.68	187	0.0	0.7	81.9
R334	RZM 2245-#(C),(R05),C79-6	4737	14.18	16.71	191	0.0	0.6	82.7
R336	RZM 2243-#(C),(R22),C79-8	6062	19.64	15.45	189	0.0	0.6	80.4
R337	RZM 2247-#(C),(WB151),C79-9	4663	14.44	16.18	193	0.0	0.6	80.4
R338-1,-2,-3	RZM R279 x R38(C), (Rz+)	5170	16.33	15.84	209	0.0	0.4	82.0
R380	RZM R280,R280Y,(Rz)	6494	19.95	16.29	184	0.0	0.0	82.5
Y954	Inc. Y854,(C54)	4115	12.92	15.91	186	0.0	0.3	83.1
R722	Inc. F$_2$(Y54 x B.m.),(C0),(C50)	4481	15.07	14.81	184	0.0	4.5	79.5
R122R3	RZM R022R2,(C3)	7540	24.36	15.52	173	0.0	0.3	81.1
R222R4	RZM R122R3,(C4)	7315	23.93	15.34	182	0.4	1.5	80.9
R322R4	RZM R122R3,(GSY)(C4)	7605	23.94	15.91	193	0.3	0.3	81.1
R322R4%	RZM R122R3,(%S)(C4)	7723	24.41	15.91	188	0.0	0.3	80.7
R322Y3	YR-ER-PMR R122Y2,(GSY)(C3)	5126	15.91	16.13	203	0.0	0.7	81.5
Mean		5723.7	18.02	15.91	190.0	0.0	0.8	81.5
LSD (.05)		1178.3	3.68	0.49	18.8	0.4	1.4	1.8
C.V. (%)		20.8	20.59	3.13	10.0	805.9	180.1	2.3
F value		10.2**	10.70**	12.01**	1.7*	0.9NS	4.4**	2.5**

Test 3194 was grown under severe rhizomania conditions. See Test 1194 and 1594 for performance under nondiseased and virus yellows. See Tests 4894, 5594, and 5994 for other tests under rhizomania conditions. Also see Tests 1294, 2094, and 5694 for performance of R22 lines and their descriptions.

A98

TEST 4894. EVALUATION/SELECTION OF R38 POLYCROSS LINES & SOURCES OF RESISTANCE IN C37 BACKGROUND, SALINAS, CA., 1994

Planted: May 10-11, 1994
Harvested: October 18-19, 1994

16 entries x 8 replications, RCB (equalized)
1-row plots, 20 ft. long

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Powdery Mildew %	RJAP %
U86-37	Inc. C37 (86443)		6434	21.68	14.82	181	7.0	82.9
R379	RZM R279,Y,R2		6282	21.59	14.55	170	6.8	82.7
R338-1,2,3	RZM R279,Y,R2 x R38(C)	(Rz),C79-1	7661	25.16	15.21	160	6.6	84.0
R338-4	R221 x R38(C)	(Rz) (WB41/42)	7725	26.25	14.73	174	6.9	82.7
R338-5	RZM 2201-#(C) x R38(C)	(R04)	7726	25.99	14.86	163	6.4	82.1
R332	RZM 2201-#(C)	(R04),C79-5	7958	27.09	14.70	183	5.5	84.1
R338-7	RZM 2202-#(C) x R38(C)	(PIO7)	7612	25.95	14.65	165	6.7	82.8
R328	RZM 2202-#(C)	(PIO7),C79-4	7365	24.81	14.86	183	7.1	82.7
R338-9	RZM 2242-#(C) x R38(C)	(Rima)	8330	27.08	15.40	160	7.0	82.6
R335	RZM 2242-#(C)	(Rima),C79-7	9063	28.94	15.66	178	6.7	83.4
R338-11	RZM 2245-#(C) x R38(C)	(R05)	8258	26.99	15.31	159	6.1	82.2
R334	RZM 2245-#(C)	(R05),C79-6	7765	24.75	15.68	163	6.1	83.7
R338-13	RZM 2243-#(C) x R38(C)	(R22)	7994	27.47	14.54	164	6.5	82.9
R336	RZM 2243-#(C)	(R22),C79-8	8056	27.96	14.39	178	6.9	82.2
R338-15	RZM 2247-#(C) x R38(C)	(WB151)	7569	25.21	15.04	163	6.1	80.9
R337	RZM 2247-#(C)	(WB151),C79-9	7627	24.78	15.38	163	6.0	82.6
Mean			7714.0	25.73	14.99	169.0	6.5	82.8
LSD (.05)			669.7	2.18	0.40	16.0	0.6	1.8
C.V. (%)			8.8	8.58	2.66	9.6	9.3	2.2
F value			7.7**	6.66**	8.32**	2.3**	4.4**	1.5NS

Test 4894 was grown under moderate rhizomania conditions. See Test 1194, 1594, 3194, 5594, and 5994 for performance under nondiseased, virus yellows, and rhizomania conditions. See Test 1194 for more detailed description of lines.

R38(C) is a composite of all sources of resistance in a C37 background. R338-#'s are mother roots from individual sources crossed to R38(C).

A99

TEST 5594. RHIZOMANIA EVALUATION BY YIELD OF SOURCES OF RESISTANCE IN C37 BACKGROUND, SALINAS, CA., 1994

16 entries x 8 replications, RCB (equalized)
1-row plots, 18 ft. long

Planted: May 23, 1994
Harvested: December 5, 1994

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Powdery Mildew %	Bolters %	RJAP %
US H11	L113401	2490	10.73	11.56	179	4.9	0.0	74.0
Rizor	RZ3/1022 (1/21/93)	5422	18.31	14.76	193	7.8	0.0	73.6
U86-37	Inc. C37, (86443)	2317	8.95	12.93	174	4.0	0.0	70.1
R379	RZM R279,Y,R2, (Rz),C79-1	3474	12.75	13.61	186	4.9	0.0	73.5
R336	RZM 2243-#(C), (R22),C79-8	5873	23.59	12.45	161	7.6	0.0	73.5
R332	RZM 2201-#(C), (R04),C79-5	3549	14.12	12.61	174	4.8	0.0	73.3
R332R2	RZM R232, (R04),C79-5	4187	17.28	12.13	179	6.0	1.9	75.2
R328	RZM 2202-#(C), (PI07),C79-4	3294	12.29	13.43	178	6.0	0.0	72.3
R328R2	RZM R228, (PI07),C79-4	3583	12.71	14.07	186	6.4	0.0	74.8
R334	RZM 2245-#(C), (R05),C79-6	4239	14.51	14.65	186	6.4	0.0	74.3
R337	RZM 2247-#(C), (WB151),C79-9	3868	13.58	14.19	182	5.1	0.0	73.3
R335	RZM 2242-#(C), (Rima),C79-7	5228	19.54	13.40	194	7.1	0.0	72.8
R338-4	R221 x R38(C), (WB41/42)	4943	17.78	13.93	172	6.3	0.0	75.2
R338-1,2,3	RZM R279 x R38(C),(Rz+)	4331	15.74	13.80	173	5.4	0.0	75.3
R139C7	RZM R039C6,(C39R)	6557	23.63	13.86	181	2.8	3.3	75.5
R222R4	RZM R122R3,(C50)	7338	28.69	12.79	193	7.1	0.0	73.6
Mean		4418.2	16.51	13.39	180.7	5.8	0.3	73.8
LSD (.05)		585.6	1.93	0.68	17.8	1.2	1.3	2.5
C.V. (%)		13.4	11.82	5.12	9.9	20.9	397.7	3.4
F value		44.7**	58.73**	13.99**	1.9*	10.1**	4.1**	2.4**

Test 5594 was grown in Field C under severe rhizomania conditions. See Tests 1194, 1594, 3194, 4894, and 5994 for performance under nondiseased, virus yellows, and rhizomania conditions. See Test 1194 for more detailed description of lines.

A100

TEST 5994. POLYCROSS OF SOURCES OF RESISTANCE TO RHIZOMANIA, SALINAS, CA., 1994

8 entries x 8 replications, RCB
1-row plots, 20 ft. long

Planted: May 23, 1994
Harvested: December 1, 1994

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
U86-37	Inc. C37 (86443)		2394	8.72	13.76	170	75.6
R379	RZM R279,Y,R2,		3253	12.08	13.45	183	75.4
R338-1,2,3(C)	RZM R279,Y,R2 x R38(C),	(Rz)	4560	16.21	14.04	167	76.0
R338-11	RZM 2245-#(C) x R38(C),	(R05)	4449	15.85	13.93	150	75.1
R338-5	RZM 2201-#(C) x R38(C),	(R04)	4185	15.90	13.18	171	75.1
R338-7	RZM 2202-#(C) x R38(C),	(PI07)	4417	16.47	13.40	157	74.2
R338-13	RZM 2243-#(C) x R38(C),	(R22)	5378	21.79	12.35	158	75.6
R338-15	RZM 2247-#(C) x R38(C),	(WB151)	4871	17.73	13.76	168	75.3
Mean			4188.3	15.59	13.48	165.5	75.3
LSD (.05)			702.5	2.43	0.71	20.0	2.9
C.V. (%)			16.7	15.50	5.25	12.0	3.8
F value			14.6**	20.32**	4.66**	2.1NS	0.3NS

Test 5994 was grown in Field C under severe rhizomania conditions. Also see Test 4894.

R38(C) = a composite of all sources of resistance in a C37 background. R338-#'s are mother roots from individual sources and backcrosses crossed to R38(C) to develop a polycross of resistant types in a C37 background.

A101

TEST 2494. NEMATODE/RHIZOMANIA YIELD EVALUATION (NON-DISEASED CONDITIONS), SALINAS, CA., 1994

Planted: April 28, 1994
Harvested: October 7, 1994

8 entries x 8 replications, RCB
1-row plots, 31 ft. long

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Powdery Mildew %	Root Rot %	RJAP %
US H11	113401	8958	31.00	14.44	223	8.4	0.0	81.6
Rhizoguard	9/21/93	9308	30.26	15.38	199	8.4	0.0	83.9
R378H52	F92-790-15H39 x R278	10534	35.61	14.79	222	6.6	0.0	82.6
N303H52	F92-790-15H39 x N103-1	9225	37.06	12.44	205	8.2	0.8	80.5
N303H15	2915aa x N103-1, (BC$_1$F$_1$)	9805	35.52	13.81	189	7.6	0.2	82.1
N203H15	1915aa x N103-1, (BC$_1$F$_1$)	9439	36.28	13.03	189	8.2	0.0	81.2
N354	NR-RZM N254-#-#(C),(BC$_2$F$_2$)	9257	32.49	14.24	203	7.3	0.0	82.1
N244	NR-RZM N144-#-#(C),(BC$_1$F$_2$)	7320	28.07	13.04	197	7.3	0.0	80.9
Mean		9230.8	33.29	13.90	203.5	7.8	0.1	81.9
LSD (.05)		893.2	3.04	0.41	16.0	0.6	0.5	1.6
C.V. (%)		9.6	9.09	2.93	7.8	7.5	372.1	1.9
F value		8.4**	9.48**	48.35**	5.5**	10.3**	2.9*	3.8**

Notes: Test 2494 was grown free of rhizomania and cyst nematode. Also see Tests 3594 (severe rhizomania, moderate nematode), 4694 (moderate rhizomania, light cyst nematode), and 5394 (severe rhizomania, moderate nematode). These tests were grown to evaluate the present status of the breeding program to combine resistance to rhizomania (Rz) and cyst nematode. Cyst nematode resistance was initially from B883 and through homozygous NR line C603/C603-1.

Entries: BC$_1$F$_1$ & BC$_1$F$_2$ = 25% germplasm from B883; BC$_2$F$_2$ = 12.5% from B883. Current breeding lines are up to BC$_4$, which will have about 4% B883. US H11 = susceptible check. Rhizoguard = rhizomania resistant hybrid from Holly Sugar. R378H52 = rhizomania resistant nematode susceptible USDA experimental hybrid. N303H52 = rhizomania susceptible, cyst nematode resistant USDA experimental hybrid. Other entries are breeding lines that combine dual resistance to rhizomania and cyst nematode; they all segregate for both resistances. N103-1 = C603-1 homozygous NR line.

Results: Very low sugar concentration is a great concern with NR germplasm. There is evidence in these tests, however, that backcrossing away from B883 will improve sugar relative to nematode susceptible checks. It was not determined yet whether additional backcrosses will solve the low sugar problem of NR breeding lines and hybrids. Even though NR genotypes have a tendency to form crown and root galls and abnormal canopy development, these aberrations do not seem to greatly influence root and sugar yield when plants are grown under high or dense populations.

TEST 2494. NEMATODE/RHIZOMANIA YIELD EVALUATION (NON-DISEASED CONDITIONS), SALINAS, CA., 1994

(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
US H11	8360	270	93.3	598	241	1238	262	6432
Rhizoguard	8783	290	94.4	524	220	1169	218	5761
R378H52	9819	276	93.2	715	234	1414	249	6721
N303H52	8159	220	88.4	1066	792	1534	315	9596
N303H15	8845	249	90.2	960	499	1613	339	9002
N203H15	8391	232	88.9	1048	768	1600	309	9619
N354	8597	264	92.8	660	308	1442	222	6791
N244	6505	232	88.7	815	691	1559	354	9685
Mean	8432.5	254.1	91.2	798.3	469.2	1446.2	283.5	7951.0
LSD (.05)	854.9	9.6	1.2	108.7	122.5	102.2	46.2	876.5
C.V. (%)	10.1	3.7	1.3	13.6	26.0	7.0	16.2	11.0
F value	9.5**	54.3**	35.3**	29.4**	33.7**	21.4**	10.5**	29.4**

A103

TEST 3594. NEMATODE/RHIZOMANIA YIELD EVALUATION, SALINAS, CA., 1994

8 entries x 8 replications, RCB
1-row plots, 20 ft. long

Planted: April 20, 1994
Harvested: October 31, 1994

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Root Rot %	RJAP %
US H11	113401	4220	14.75	14.32	218	0.0	84.9
Rhizoguard	9/21/93	6875	22.28	15.46	208	0.0	83.8
R378H52	F92-790-15H39 x R278	8990	28.30	15.93	201	0.0	84.3
N303H52	F92-790-15H39 x N103-1	5712	21.46	13.34	201	1.3	87.2
N303H15	2915aa x N103-1,(BC$_1$F$_1$)	8554	28.40	15.05	189	0.0	83.7
N203H15	1915aa x N103-1,(BC$_1$F$_1$)	8419	29.35	14.48	186	0.0	84.1
N354	NR-RZM N254-#-#(C),(BC$_2$F$_2$)	8038	25.60	15.75	199	0.0	82.5
N244	NR-RZM N144-#-#(C),(BC$_1$F$_2$)	6203	21.25	14.61	198	0.0	86.6
Mean		7126.4	23.92	14.87	200.1	0.2	84.6
LSD (.05)		956.4	3.29	0.82	19.3	0.7	3.4
C.V. (%)		13.4	13.69	5.49	9.6	436.3	4.0
F value		24.4**	18.26**	8.81**	2.2*	3.4**	1.7NS

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
US H11	3966	269	94.0	254	544	1274	69	5747
Rhizoguard	6506	293	94.6	369	432	1102	130	5502
R378H52	8523	302	94.8	467	414	1189	111	5475
N303H52	5150	240	90.0	562	1196	1411	116	8816
N303H15	7922	279	92.6	632	654	1358	183	7426
N203H15	7629	263	90.8	790	878	1470	219	8823
N354	7565	297	94.2	473	433	1241	157	6106
N244	5650	266	91.1	553	886	1342	230	8641
Mean	6613.9	276.1	92.8	512.5	679.5	1298.4	151.9	7066.9
LSD (.05)	907.8	17.4	1.2	101.3	211.6	106.7	36.6	929.3
C.V. (%)	13.7	6.3	1.3	19.7	31.0	8.2	24.0	13.1
F value	24.3**	11.3**	21.8**	20.9**	14.4**	10.4**	18.8**	21.9**

<u>Note</u>: See Tests 2494, 4694, and 5394. Test 3594 had severe rhizomania and moderate cyst nematode infestation.

A104

TEST 4694. NEMATODE/RHIZOMANIA YIELD EVALUATION, SALINAS, CA., 1994

8 entries x 8 replications, RCB
1-row plots, 20 ft. long

Planted: May 11, 1994
Harvested: October 13, 1994

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Powdery Mildew %	RJAP %
US H11	113401	5745	22.42	12.82	181	8.1	85.5
Rhizoguard	9/21/93	7283	25.69	14.22	174	6.7	84.8
R378H52	F92-790-15H39 x R278	8933	31.34	14.24	180	3.4	84.4
N303H52	F92-790-15H39 x N103-1	6558	27.56	11.87	179	7.8	81.2
N303H15	2915aa x N103-1, (BC₁F₁)	7884	30.73	12.84	161	7.3	82.2
N203H15	1915aa x N103-1, (BC₁F₁)	7543	30.71	12.32	166	7.6	81.6
N354	NR-RZM N254-#-#(C), (BC₂F₂)	7878	29.24	13.47	173	7.2	83.5
N244	NR-RZM N144-#-#(C), (BC₁F₂)	5913	24.72	12.02	167	7.4	80.9
Mean		7217.1	27.80	12.98	172.7	6.9	83.0
LSD (.05)		755.2	2.94	0.58	11.9	0.5	2.2
C.V. (%)		10.4	10.51	4.43	6.9	6.9	2.6
F value		16.7**	9.99**	20.74**	3.2**	75.6**	5.4**

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
US H11	5387	241	93.7	357	346	1114	139	5311
Rhizoguard	6833	267	93.8	450	330	1131	202	5895
R378H52	8384	267	93.9	549	247	1197	203	5784
N303H52	5905	214	90.0	653	685	1288	236	7863
N303H15	7079	231	89.8	806	562	1578	296	8729
N203H15	6855	224	90.9	689	562	1269	237	7393
N354	7294	249	92.6	584	370	1330	215	6664
N244	5327	217	90.1	586	590	1258	282	7889
Mean	6632.9	238.7	91.9	584.2	461.5	1270.6	226.2	6941.1
LSD (.05)	701.4	12.7	1.7	132.6	148.6	202.8	41.8	1257.4
C.V. (%)	10.5	5.3	1.8	22.6	32.1	15.9	18.4	18.0
F value	17.8**	22.2**	9.8**	8.9**	9.0**	4.2**	11.4**	7.5**

Note: See Tests 2494, 3594, and 5394. Test 4694 had moderate rhizomania and light cyst nematode infestation.

TEST 5394. NEMATODE/RHIZOMANIA YIELD EVALUATION, SALINAS, CA., 1994

8 entries x 8 replications, RCB
1-row plots, 18 ft. long

Planted: May 23, 1994
Harvested: December 6, 1994

| Variety | Description | Acre Yield | | | Beets/ 100' | Powdery Mildew | RJAP |
		Sugar Lbs	Beets Tons	Sucrose %	No.	%	%
US H11	L113401	2102	11.15	9.43	158	5.3	72.0
Rhizoguard	9/21/93	4503	19.25	11.70	190	6.5	76.0
R378H52	F92-790-15H39 x R278	4998	20.61	12.11	199	3.6	75.0
N303H52	F92-790-15H39 x N103-1	2604	16.63	7.81	176	5.9	68.3
N303H15	2915aa x N103-1,(BC$_1$F$_1$)	4448	22.56	9.86	177	7.1	71.9
N203H15	1915aa x N103-1,(BC$_1$F$_1$)	4313	23.40	9.19	181	7.8	71.2
N354	NR-RZM N254-#-#(C),(BC$_2$F$_2$)	4162	18.80	11.05	183	5.9	74.2
N244	NR-RZM N144-#-#(C),(BC$_1$F$_2$)	3964	21.79	9.15	172	6.8	71.3
Mean		3886.7	19.27	10.04	179.4	6.1	72.5
LSD (.05)		564.4	2.31	0.79	19.5	1.0	3.4
C.V. (%)		14.5	11.94	7.85	10.8	16.0	4.6
F value		25.4**	23.55**	27.51**	3.2**	13.7**	4.4**

Note: See Tests 2494, 3594, and 4694. Test 5394 was grown at a different site than Spence Field Tests 2494, 3594 and 4694. It was under heavier soil conditions. It was hand harvested rather than machine harvested. Test 5394 had severe rhizomania and moderate nematode infestation.

A106

VARIETY TRIALS, BRAWLEY, CALIFORNIA, 1993-94
USDA-ARS. Irrigated Desert Research Station

Tests were located in three sections of Field K. Tests B194-B494 were in the first 64 rows on the north side. Test B594 was in a section that has been in rhizomania trials since 1991-92. Tests B694-B994 were in an area south of B594 set up for rhizomania tests. Field K has a long history of a 3-year sugarbeet rotation but, except for Test B594, had not been in sugarbeet since 1989 or before. All trial areas were prefertilized with 117 units/ acre nitrogen and 146 units per acre phosphorus. Previous crops included cereals and vegetables.

Summary: Arrangement of 1993-94 Tests

Test No.	Entries per Test	No. Reps	Rows per Plot	Plot Length	Harv Date	Test Design	Sugar Samples Plot
B194	16	8	1	27	5/16	RCB	1
B294	32	8	1	27	5/17	RCB	1
B394	32	8	1	27	5/19	RCB	2
B494	32	8	1	27	5/18	RCB	1
B594[1]	4	4	1	30	5/21,7/1	S-S-P	2
B694	12	8	1	18	5/20	RCB	1
B794	48	8	1	18	5/23	RCB	1
B894[2]	96	4	1	9	7/01	RCB	-
B994[2]	144	2	1	9	7/01	RCB	-

Tests B194-B494 planted 9/21/93. Test B594 planted 10/15/93. Tests B694-B994 planted 9/28/93. Watered by sprinkler to obtain emergence, then, except B594, by furrow irrigation on 10/26/93, 12/7/93, 1/10/94, 2/22/94, 3/28/94, 4/25/94. B594 by sprinkler on 10/13/93, 10/28, 12/6, 1/7/94, 2/1, 2/28, 3/28, 4/25/94. No pesticides or herbicides were applied. Thinned 11/23-24/93 and hand weeded as needed.

[1]Control of rhizomania tests: 4 varieties, 4 soil treatments (check, methylbromide, vapam, solarization), and 2 dates of harvest (5/21/94 and 7/1/94).
[2]Late season root rot tests to evaluate effects of rhizomania and high temperatures on all known sources of resistance to rhizomania and progeny lines.

Remarks - Nitrogen status was moderate to high. Tests were off water from 17 to 24 days, and were still lush. Powdery mildew was not controlled and moderate at harvest. First symptoms were observed about March 10. Empoasca infestation was moderate. Bolting was higher than normal. BWYV symptoms were evident prior to harvest. Rhizomania and cyst nematode were not observed in tests B194-B494, but occurred in tests B594-B994. Test B594 was in cooperation with Dr. Anne Wrona, U.C. Cooperative Extension, Imperial County.

Acknowledgements - Cliff Brown, IDRS, for managing these trials. Holly Sugar at Brawley for field plot harvesting equipment and running sugar samples.

TEST B294. EVALUATION OF EXPERIMENTAL HYBRIDS, 1993-94 (B294)

Planted: September 21, 1993
Harvested: May 17, 1994

16 entries x 8 replications, RCB (equalized)
1-row plots, 27 ft. long

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/ 100' No.	Clean Beets %	NO3-N Score
Checks								
R338H52	F92-790-15H39 x R38-#	8813	35.40	12.45	10.1	131	93.9	211
HH 41	L412307	8636	33.51	12.91	3.9	133	92.9	156
US H11	L113401	7339	29.89	12.28	0.9	134	91.9	216
N303H52	F92-790-15H39 x N103-1	5966	33.29	8.99	1.0	133	96.0	378
R80 tester								
R380H52	F92-790-15H39 x R280,Y	9638	39.84	12.10	8.9	136	94.6	201
R380H50	F92-790-15CMS x R280,Y	9292	36.17	12.83	16.2	141	93.7	207
R76 tester								
R376H52	F92-790-15H39 x R276,Y	9139	39.87	11.49	11.2	139	95.2	249
R376H39	91-762-17CMS x R276,Y	8950	38.91	11.55	7.2	128	95.3	259
R376H53	F92-790-15H97 x R276,Y	8828	36.19	12.20	12.8	128	95.2	240
R376H50	F92-790-15CMS x R276,Y	8705	36.66	11.96	15.3	137	95.3	274
R376H46	F92-790- 6CMS x R276,Y	8294	32.70	12.70	19.3	135	95.7	258
R376H51	F92-790-15H26 x R276,Y	8164	32.80	12.48	12.4	137	95.0	171
R376H54	F92-790-54CMS x R276,Y	8141	33.29	12.28	21.3	131	95.1	230
C76-# tester								
R384H51	F92-790-15H26 x R176-43,-89-#	9677	36.29	13.33	1.8	130	94.9	120
R384H50	F92-790-15CMS x R176-43,-89-#	9396	36.23	12.96	5.2	136	94.8	158
R384H52	F92-790-15H39 x R176-43,-89-#	9212	36.25	12.70	3.5	136	95.0	170
R282H37	9807HO x R176-43,-89	9122	38.04	12.00	19.1	120	96.5	205

TEST B294. EVALUATION OF EXPERIMENTAL HYBRIDS, 1993-94 (B294)
(cont.)

Variety	Description[1]	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Score
R78 tester								
R378H39	91-762-17CMS x R278,Y	10584	41.28	12.84	5.9	132	95.1	148
R378H52	F92-790-15H39 x R278,Y	9955	39.04	12.71	9.1	128	95.3	140
R378H46	F92-790-6CMS x R278,Y	9407	34.41	13.68	16.6	129	94.9	141
R278H37	84-306CMS x R078	9364	39.29	11.89	22.3	122	96.5	232
R378H50	F92-790-15CMS x R278,Y	9066	35.39	12.88	16.3	134	93.4	161
R378H54	F92-790-54CMS x R278,Y	8642	32.16	13.45	15.8	133	95.0	145
Popn-915 tester								
3915H52	F92-790-15H39 x 2915,...,2911	9808	39.93	12.27	5.7	132	93.0	222
3915H39	91-762-17CMS x 2915,...,2911	9685	39.43	12.31	2.8	134	93.5	191
3915H50	F92-790-15CMS x 2915,...,2911	9537	38.07	12.55	14.9	130	95.0	231
3915H54	F92-790-54CMS x 2915,...,2911	8922	35.56	12.53	11.8	136	95.4	215
3915H46	F92-790-6CMS x 2915,...,2911	8903	34.31	13.01	19.6	128	94.2	140
3915H20	87-309H3 x 2915,...,2911	8607	33.82	12.76	2.4	128	95.4	162
C918 tester								
3918H52	F97-790-15H39 x 1913,1915-#	10048	37.33	13.42	12.0	132	93.2	133
3918H50	F92-790-15CMS x 1913,1915-#	9416	35.30	13.36	14.8	124	93.1	129
3918H39	91-762-17CMS x 1913,1915-#	9074	37.24	12.19	0.6	127	93.0	183
Mean		9010.3	36.18	12.47	10.7	131.7	94.6	196.1
LSD (.05)		896.6	3.12	0.80	5.4	13.5	1.4	67.3
C.V. (%)		10.1	8.76	6.55	51.9	10.4	1.5	34.8
F value		6.9**	5.93**	8.30**	11.5**	1.0NS	5.2**	5.1**

[1]R280,Y = R280 & R280Y = versions of C54Rz. R276,Y = R276 & R276Y = versions of C31/6Rz.
R176-43;-89-# = composite of C76-43 & C76-89. R078,R278,Y = versions of C46/2Rz. 2911,....,
2915 = composite of M,S^f,A:aa,Rz population. 1913,1915-# = composite of S_1 lines from
popn-913 & popn-915; similar to popn-C918. R38-# = composite of sources of rhizomania
resistance in C37 background. N103-1 = C603-1 = cyst nematode resistant line. 790-#CMS =
C790-68CMS x C790-# T-O. H39 = C762-17CMS x T-O. H26 = C309CMS x T-O. H97 = C796-43CMS x T-O.
9807HO = C306/2CMS. 309H3 = C562CMS x C309. See note for Test B194.

A109

TEST B494. EVALUATION OF HYBRID PERFORMANCE OF MONOGER LINES, BRAWLEY, CA., 1993-94

Planted: September 21, 1993
Harvested: May 18, 1994

32 entries x 8 replications, RCB (equalized)
1-row plots, 27 ft. long

Variety	Description[1]	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Score
Checks								
3918H50	92-790-15CMS x 1913,1915-#	9486	30.90	15.4	10.4	130	92.6	53
R380H20	87-309H3 x R280,Y	9469	33.05	14.3	2.6	143	94.9	76
3918H20	87-309H3 x 1913,1915-#	9422	30.29	15.6	1.7	138	93.0	52
HH 41	L412307	9260	32.92	14.1	1.5	138	94.5	87
R380H8	F82-546H3 x R280,Y	8979	31.48	14.2	1.8	132	95.0	116
US H11	L113401	7478	27.08	13.8	2.0	141	92.1	95
mm CMS female								
R280H37	9807HO x R080	10591	38.26	13.9	8.4	132	95.5	136
R380H50	92-790-15CMS x R280,Y	10575	35.88	14.7	16.2	137	94.8	110
R380H39	91-762-17CMS x R280,Y	10366	36.47	14.2	2.8	136	94.0	81
R380H46	92-790- 6CMS x R280,Y	9674	32.69	14.8	14.4	135	94.1	98
R380H89	88-790-68CMS x R280,Y	9618	32.89	14.7	16.1	137	95.2	89
R380H54	92-790-54CMS x R280,Y	9006	31.40	14.4	15.9	142	94.1	111
R380H97	0796-43HO x R280,Y	8809	30.41	14.5	15.6	123	95.3	97
R380H26	87-309CMS x R280,Y	8738	29.20	15.0	12.2	136	94.4	81
R380H3	F82-562HO x R280,Y	8564	30.38	14.1	2.5	135	95.3	129
F₁mmCMS female								
R380H52	F92-790-15H39 x R280,Y	11128	37.43	14.9	7.9	138	94.2	82
R380H48	F92-790- 6H39 x R280,Y	10945	37.49	14.6	2.7	130	95.6	59
R380H56	F92-790-54H39 x R280,Y	10790	37.02	14.6	9.5	136	95.1	91
R380H18	88-790-68H26 x R280,Y	9934	33.06	15.0	17.2	144	94.2	72

A110

(cont.)

Variety	Description[1]	Acre Yield		Sucrose	Bolters	Beets/100'	Clean Beets	NO3-N
		Sugar Lbs	Beets Tons	%	%	No.	%	Score
F₁mmCMS female (cont.)								
R380H47	92-790- 6H26 x R280,Y	9850	32.48	15.1	7.1	142	95.6	88
R380H57	F92-790-54H97 x R280,Y	9375	31.88	14.7	15.4	136	93.7	91
R380H51	92-790-15H26 x R280,Y	9331	32.30	14.4	10.3	144	94.2	104
R380H49	F92-790- 6H97 x R280,Y	9213	31.20	14.8	8.2	127	94.1	78
R380H53	F92-790-15H97 x R280,Y	9184	32.04	14.3	7.0	125	94.2	101
R380H55	F92-790-54H26 x R280,Y	9038	31.27	14.4	14.2	133	94.3	94
Population hybrids								
R380H93	2890aa x R280,Y	9842	33.89	14.5	8.7	140	94.9	79
R380H88	2888aa x R280,Y	9741	33.14	14.7	10.8	140	95.4	91
R380H87	2889aa x R280,Y	9661	33.74	14.3	6.9	139	95.7	86
R380H67	2867aa x R280,Y	9496	33.15	14.3	7.7	136	95.1	119
R380H59	2859aa x R280,Y	9170	31.65	14.5	9.8	135	95.5	81
R380H91	2891aa x R280,Y	9079	30.52	14.9	11.7	129	95.6	77
R380H65	2865aa x R280,Y	8954	30.49	14.6	10.8	136	93.9	88
Mean		9523.9	32.69	14.6	9.1	135.7	94.6	90.4
LSD (.05)		933.5	2.94	0.7	6.3	12.5	1.5	40.6
C.V. (%)		10.0	9.12	4.9	70.0	9.4	1.6	45.6
F value		5.1**	5.96**	2.5**	5.0**	1.4NS	2.7**	1.8*

[1]R280,Y = R280 & R280Y = versions of C54Rz. 1913,1915-# = selected S₁ lines from popn-913,-915; similar to popn-C918. 9807HO = C306/2CMS. 546H3 = C562HO x C546. C309H3 = C562HO x C309. 790-#CMS = 790-68CMS x 790-#T-O. H26 = C309CMS x T-O. H39 = C762-17CMS x T-O. H97 = C796-43CMS x T-O. 2859 = C859. 2890 = C890. 2865 = popn-C310. 2867,2889,2888,2891 = A:aa,Sᶠ,Rz populations that segregate for mm & Rz.

A111

TEST B394. AREA 5 CODED VARIETY TRIAL, BRAWLEY, CA., 1993-94

Planted: September 21, 1993
Harvested: May 19, 1994

32 entries x 8 replications, RCB (equalized)
1-row plots, 27 ft. long

Code	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
26	HM 3012	Hill-MH	11907	39.61	15.1	139	5.2	96.1	61.1
15	HM 3013	Hill-MH	11568	38.09	15.2	136	2.3	94.4	87.8
17	OBG6499	Beta	11518	39.79	14.4	122	32.8	95.6	91.4
22	SS-IV2	Spreckels	11080	37.35	14.9	139	3.5	95.3	76.9
31	HH 51	Holly	10974	36.99	14.8	138	0.3	95.2	73.4
7	HM 3043	Hill-MH	10883	34.65	15.7	130	14.2	95.4	59.3
12	1BG6426	Beta	11231	39.58	14.2	134	1.1	95.3	75.5
18	H90636	Spreckels	10721	35.25	15.3	136	7.6	95.1	62.3
5	HM 3044	Hill-MH	10824	34.83	15.5	136	1.4	93.4	37.6
30	3BG6382	Beta	10600	34.54	15.3	136	6.6	93.2	60.9
14	SS-IV1	Spreckels	10548	35.49	14.9	125	7.2	96.9	63.0
27	93HX30	Holly	10298	34.82	14.8	136	0.6	95.1	70.3
20	H93834	Spreckels	10011	33.74	14.9	126	11.2	94.1	65.1
4	2BG6068	Beta	10346	35.67	14.5	136	5.4	93.2	72.7
9	H92559	Spreckels	9866	32.77	15.1	138	0.7	95.2	110.9
21	93HX32	Holly	10080	32.71	15.4	140	0.0	92.3	45.2
19	93HX31	Holly	10033	34.85	14.4	137	1.1	94.1	52.2
29	HM 3005	Hill-MH	9948	32.59	15.4	127	0.9	92.8	62.5
8	OBG6178	Beta	9992	32.93	15.2	127	2.1	93.5	67.4
6	92HX02	Holly	9671	31.72	15.3	131	2.2	95.2	74.3
28	HH 41	Holly	9838	33.55	14.7	123	3.4	94.9	51.2
2	93HX01	Holly	9887	33.56	14.8	122	0.8	95.9	77.4
32	Beta 4684	Beta	9772	31.92	15.4	135	1.5	95.5	59.3
10	93HX08	Holly	9512	31.20	15.3	134	3.4	94.9	68.0

(cont.)

Code	Variety	Source	Acre Yield		Sucrose	Beets/100'	Bolters	Clean	NO3-N
			Sugar	Beets					
			Lbs	Tons	%	No.	%	%	Mean
3	HM 3022	Hill-MH	9638	32.05	15.0	132	2.8	94.8	72.6
25	H92570	Spreckels	9280	30.13	15.4	130	1.4	94.4	81.4
23	PM 9	Hill-MH	9022	29.57	15.3	140	42.0	92.7	53.2
1	Beta 4823	Beta	9100	30.51	14.9	136	2.3	92.5	75.8
24	HH 77	Holly	9198	32.33	14.2	132	1.7	93.4	66.8
11	US H11	Standard	8797	31.53	13.9	136	0.7	93.3	91.2
16	OBG6392	Beta	8828	29.67	14.9	102	0.0	93.9	70.2
13	HH 79	Holly	8883	29.50	15.1	129	0.3	92.3	70.2
Mean			10120.4	33.86	15.0	131.8	5.2	94.4	69.0
LSD (.05)			1053.8	3.40	0.6	12.7	3.8	1.5	32.8
C.V. (%)			10.6	10.19	4.2	9.8	73.6	1.6	48.2
F value			5.0**	5.73**	3.5**	2.8**	45.3**	5.1**	1.5NS

Note: Powdery mildew and Empoasca leaf hoppers were moderate. BWYV infection was evident. Test was harvested 20 days off water and soil was moist. Nitrogen status appeared to be moderately high. No pesticides or herbicides were used. Stands were good. No evidence of rhizomania or cyst nematode.

TEST B394. AREA 5 CODED VARIETY TRIAL, BRAWLEY, CA., 1993-94

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH$_2$-N ppm	Impur. Value
26	HM 3012	10768	273	90.4	1140	312	1945	368	9451
15	HM 3013	10576	277	91.4	991	302	1820	323	8675
17	OBG6499	10275	258	88.9	1243	399	2560	277	10430
22	SS-IV2	10087	271	91.0	993	307	1905	313	8810
31	HH 51	10011	270	91.2	963	242	2005	300	8712
7	HM 3043	9992	288	91.8	891	301	1828	312	8592
12	1BG6426	9958	252	88.5	1273	392	2329	371	10716
18	H90636	9792	279	91.3	929	291	1947	302	8753
5	HM 3044	9762	279	90.0	1062	322	2050	425	10290
30	3BG6382	9687	281	91.4	913	243	2006	304	8755
14	SS-IV1	9625	272	91.2	923	356	1792	311	8683
27	93HX30	9375	270	91.1	923	298	1930	304	8753
20	H93834	9178	272	91.5	833	279	1888	271	8272
4	2BG6068	9117	256	88.1	1229	389	2587	372	11369
9	H92559	9078	277	92.0	788	272	1802	264	7967
21	93HX32	9054	276	89.4	1026	240	2235	450	10700
19	93HX31	8996	259	89.6	1036	248	2240	369	9971
29	HM 3005	8972	278	90.2	975	349	2108	368	9989
8	OBG6178	8965	273	89.6	1027	327	2195	400	10430
6	92HX02	8898	281	91.9	773	264	1827	283	8178
28	HH 41	8875	264	90.0	963	288	2047	385	9787
2	93HX01	8871	265	89.6	1016	358	2175	360	10113
32	Beta 4684	8800	277	90.1	972	335	2135	374	10065
10	93HX08	8748	281	92.0	764	248	1728	308	8109

TEST B394.   AREA 5 CODED VARIETY TRIAL, BRAWLEY, CA., 1993-94

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH_2-N ppm	Impur. Value
3	HM 3022	8585	268	89.0	1053	330	2292	416	10840
25	H92570	8302	277	89.5	978	330	2236	418	10717
23	PM 9	8244	280	91.4	778	227	2098	280	8701
1	Beta 4823	8191	267	89.6	910	311	2071	410	10162
24	HH 77	8157	252	88.5	1042	254	2327	431	10803
11	US H11	7997	253	90.6	800	240	1718	360	8549
16	OBG6392	7928	267	89.6	899	315	2058	408	10119
13	HH 79	7926	268	89.1	957	232	2258	464	10866
Mean		9149.7	270.7	90.3	970.7	300.0	2066.9	353.2	9572.8
LSD (.05)		1014.0	14.5	2.1	216.3	90.9	355.7	100.7	1902.8
C.V. (%)		11.2	5.4	2.3	22.6	30.8	17.5	29.0	20.2
F value		4.6**	3.3**	2.3**	2.8**	2.2*	3.0**	2.5**	2.2**

TEST B194. EVALUATION OF HYBRIDS OF LINES FROM POPNS-909,-911,&-913, BRAWLEY, CA., 1993-94

16 entries x 8 replications, RCB (equalized)
1-row plots, 27 ft. long

Planted: September 21, 1993
Harvested: May 16, 1994

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Score
Checks								
R384H50	F92-790-15CMS x R176-43,-89-#	9666	36.39	13.28	7.4	140	95.1	168
3915H50	F92-790-15CMS x 2915,...,2911	9579	37.32	12.83	16.3	146	93.8	213
R380H50	F92-790-15CMS x R280,Y	9181	35.15	13.01	17.7	135	94.6	193
HH 41	L412307	9153	35.59	12.89	5.2	144	94.5	193
3918H50	F92-790-15CMS x 1913,1915-#	8971	34.86	12.84	17.3	128	94.0	179
US H11	L113401	8240	32.03	12.85	1.2	123	92.6	205
Topcross hybrids								
3913-22H50	F92-790-15CMS x 2913-22	9957	37.74	13.20	6.5	130	94.3	184
3909-34H50	F92-790-15CMS x C909-34	9637	37.03	12.99	19.4	125	94.3	206
3913-25H50	F92-790-15CMS x 2913-25	9575	35.99	13.34	8.9	120	94.3	176
3913-18H50	F92-790-15CMS x 2913-18	9533	36.56	13.03	8.7	134	94.4	196
3913- 5H50	F92-790-15CMS x 2913- 5	9478	37.63	12.63	7.6	135	94.6	198
3911-50H50	F92-790-15CMS x C911-50	9470	37.27	12.72	20.7	135	94.9	174
3909-37H50	F92-790-15CMS x C909-37	9293	36.64	12.67	6.4	129	95.5	208
3911- 4H50	F92-790-15CMS x C911- 4	9292	35.89	12.94	7.1	127	93.3	180
3911-12H50	F92-790-15CMS x C911-12	9091	33.51	13.57	7.0	130	94.4	141
3911-14H50	F92-790-15CMS x C911-14	9000	34.59	13.03	16.5	128	93.8	187
Mean		9319.8	35.89	12.99	10.9	131.8	94.3	187.6
LSD (.05)		838.8	2.71	0.65	8.4	15.1	1.2	46.2
C.V. (%)		9.1	7.63	5.06	77.9	11.6	1.7	24.9
F value		1.7NS	2.62NS	1.21NS	4.0**	1.8*	2.5*	1.2NS

[1]R280,Y = R280 and R280Y = versions of C54Rz. R176-43;-89-# = composite of C76-43 and C76-89.
2911,...,2915 = composite of M,S^f,A:aa,Rz populations. 1913,1915-# = composite of selected S$_1$
lines from popn-913 and -915; similar to popn-C918. F92-790-15CMS = C790-68CMS x C790-15.
Note: Test was harvested 17 days off water and was wet. Plants appeared to be lush and under
high nitrogen status. Diseases and pests were minimal, but powdery mildew and Empoasca leaf
hoppers were moderate and winter infection with BWYV was apparent. Bolting was higher than
usual. Test was grown without any pesticides or herbicides.

TEST B694. EVALUATION OF HYBRIDS UNDER RHIZOMANIA CONDITIONS, BRAWLEY, CA., 1993-94

Planted: September 28, 1993
Harvested: May 20, 1994

12 entries x 8 replications, RCB
1-row plots, 18 ft. long

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/ 100' No.	Clean Beets %	NO3-N Score
Checks								
HH 41	L412307	4773	21.51	10.9	0.0	131	94.4	116
US H11	L113401	3143	15.70	9.7	0.0	131	89.6	160
Topcrosses								
R380H52	F92-790-15H39 x R280,Y	6552	26.50	12.4	1.9	138	94.0	235
R378H52	F92-790-15H39 x R278,Y	6250	25.80	12.1	3.9	141	94.7	188
3915H52	F92-790-15H39 x 2915,...,2911	6243	27.94	11.1	1.7	138	93.2	264
R376H52	F92-790-15H39 x R276,Y	5592	24.08	11.6	5.9	131	95.2	208
R338H52	F92-790-15H39 x R38-#	5437	23.00	11.6	3.6	140	91.5	204
Populations Hybrids								
3915H93	2890aa x 2915,...,2911	6238	26.10	11.9	4.1	127	93.0	189
R380H93	2890aa x R280,Y	6171	23.86	12.9	5.0	125	94.9	217
R380H59	2859aa x R280,Y	5985	23.75	12.5	2.1	129	95.6	236
3915H65	2865aa x 2915,...,2911	5834	25.21	11.5	3.4	131	95.0	318
R380H65	2865aa x R280,Y	5413	21.96	12.4	8.3	132	95.3	283
Mean		5636.0	23.78	11.7	3.3	132.9	93.9	218.0
LSD (.05)		894.1	3.33	0.9	3.9	13.2	2.3	85.7
C.V. (%)		15.9	14.05	7.9	118.3	10.0	2.4	39.5
F value		8.5**	7.21**	6.8**	3.0**	1.2NS	4.9**	3.2**

[1]See footnotes for Tests B294 and B494.

Note: Tests B694 & B794 were in Field K but separated from Tests B194-B494. These tests were grown under mild to moderate rhizomania conditions. From the area where B594 was grown under severe rhizomania conditions, soil was screened and broadcast over Tests B694-B994 area in April 1993. Sugarbeets were then grown from April until June, 1993 to increase inoculum and uniformity. Based upon appearance at harvest in 1994, distribution of rhizomania was variable -- i.e., some plots were more severely infected than others and some plants within plots more severe than others. This variability in infection increased CV's. Rhizomania symptoms were not typical of what is seen at Salinas. It appeared that seedlings in the fall of 1993 were infected and the taproot damaged. Subsequently under cooler conditions, rhizomania became inactive. The roots then sprangled and grew nearly normally. Roots from the susceptible border were BNYVV positive (ELISA) when tested 5/3/94.

A117

TEST B794. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES, BRAWLEY, CA., 1993-94

48 entries x 8 replications, RCB (equalized)
1-row plots, 27 ft. long
3 sets, 16 x 8 RCB (equalized)

Planted: September 28, 1993
Harvested: May 20 & 23, 1994

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Score

Set 1: B794-1 (16 varieties x 8 reps, RCB)

Variety	Description[1]	Sugar Lbs	Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Score
Checks								
Rizor	RZ3/1022 (1993)	7747	26.68	14.5	0.0	143	94.7	197
Rhizoguard	893301	5195	20.98	12.4	0.6	129	95.9	165
HH 41	L412307	5099	22.19	11.3	0.0	134	90.2	96
US H11	L113401	3595	18.08	9.8	0.0	139	88.8	141
Topcrosses								
R222R4H20	87-309H3 x RZM R122R3	6340	26.15	12.1	17.5	138	91.1	265
R380H20	87-309H3 x R280,Y	6329	25.39	12.5	0.9	142	93.6	185
R376-43-14H20	89-309H3 x R176-43-14	6054	23.90	12.7	0.0	137	94.9	110
R378H20	87-309H3 x R278,Y	6025	23.92	12.6	3.0	145	92.9	162
R376-43-CH20	89-309H3 x R176-43-#(C)	6018	24.88	12.1	0.0	142	95.1	158
R376-43-15H20	89-309H3 x R176-43-15	5915	22.86	12.9	0.0	131	93.6	120
R376-89-18H20	89-309H3 x R176-89-18	5428	22.93	11.7	0.5	136	94.0	109
3915H20	87-309H3 x 2915,...,2911	5255	21.89	12.0	0.5	140	92.4	155
R376H20	87-309H3 x R276,Y	5130	22.77	11.3	2.0	138	94.2	228
R376-89-CH20	89-309H3 x R176-89-#(C)	5121	21.93	11.7	0.0	136	91.8	191
R384H20	87-309H3 x R176-43,-89-#	5027	20.65	11.9	1.5	138	92.7	135
R376-89-5H20	89-309H3 x R176-89-5	4713	18.29	12.9	0.0	135	91.2	104
Mean		5561.9	22.72	21.2	1.7	137.7	93.0	157.6
LSD (.05)		909.2	3.52	0.9	2.2	12.3	2.7	67.4
C.V. (%)		16.5	15.67	7.9	132.9	9.0	2.9	43.2
F value		7.9**	3.88**	8.6**	30.8**	0.9NS	4.2**	3.9**

(cont.)

| Variety | Description[1] | Acre Yield | | Sucrose | Bolters | Beets/ 100' | Clean Beets | NO3-N |
		Sugar Lbs	Beets Tons	%	%	No.	%	Score

Set 1: B794-1 (16 varieties x 8 reps, RCB) (cont.)

Note: See footnote for Test B694.

[1]87-309H3 = C562CMS x C309. R122R3 = RZM (Y54 x B.maritima). 2911,...,2915 = composite of MM,S[f],A:aa,Rz popns. R278,Y = C46/2Rz. R280,Y = C54Rz. R176-43;-89-# = Composite of C76-43 & C76-89. R276,Y = C31/6Rz. R176-43-#(C) = C76-43. R176-89-#(C) = C76-89. R176-43-# & R176-89-# = selected FS families.

TEST B794. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES, BRAWLEY, CA., 1993-94
48 entries x 8 replications, RCB (equalized). ANOVA to compare maeans across sets of entries.

	Sugar Lbs	Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Score
Mean	5813.0	23.26	12.5	0.8	137.1	92.1	129.3
LSD (.05)	940.6	3.46	1.0	1.6	12.7	2.7	64.7
C.V. (%)	16.4	15.09	8.0	207.3	9.4	3.0	50.8
F value	3.5**	2.81**	4.1**	19.4**	1.0NS	3.4**	3.3**

TEST B794. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES, BRAWLEY, CA., 1993-94
(cont.)

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/ 100' No.	Clean Beets %	NO3-N Score
Set 2: B794-2 (16 varieties x 8 reps, RCB)								
Checks								
3918H20	87-309H3 x 1913-#,1915-#	5738	22.83	12.6	1.0	140	92.3	97
3918-#(C)H20	87-309H3 x 1913-#,1915-#(C)	5273	21.12	12.4	0.4	143	92.1	93
3911-14H20	87-309H3 x C911-14	6907	26.79	12.9	1.0	136	92.6	156
3913-70H20	87-309H3 x 1913-70(S₁)	6614	23.69	13.9	0.0	138	92.0	83
3911- 4H20	87-309H3 x C911- 4	6444	24.69	13.2	0.0	138	92.7	98
3909-37H20	87-309H3 x C909-37	6424	25.63	12.5	1.2	137	94.4	109
3911-50H20	87-309H3 x C911-50	6359	24.96	12.7	1.0	140	93.6	136
3913- 5H20	87-309H3 x 2913- 5	6177	25.14	12.2	0.0	147	90.9	123
3913-25H20	87-309H3 x 2913-25	6166	24.53	12.6	0.0	132	93.2	163
3913-71H20	87-309H3 x 1913-71(S₁)	6109	25.54	12.0	0.0	140	92.9	123
3913-22H20	87-309H3 x 2913-22	6038	24.12	12.6	0.0	139	92.5	129
3909-34H20	87-309H3 x C909-34	5923	25.28	11.6	0.0	129	93.9	169
3911-12H20	87-309H3 X C911-12	5775	22.71	12.8	0.5	133	91.6	126
3913-18H20	87-309H3 x 2913-18	5564	22.56	12.3	0.0	142	90.6	84
3913-51H20	87-309H3 x 1913-51(S₁)	5101	21.68	11.6	0.0	137	87.3	55
3913-3H20	87-309H3 x 1913-3(S₁)	5031	20.26	12.4	0.0	140	89.9	42
Mean		5977.6	23.84	12.5	0.3	138.2	92.0	111.4
LSD (.05)		886.7	3.36	0.9	1.0	13.2	2.3	58.5
C.V. (%)		15.0	14.23	7.0	321.6	9.6	2.5	53.1
F value		2.9**	2.31*	48.5**	1.6NS	0.9NS	4.6**	3.0**

Note: See footnote for Test B694.
[1]87-309H3 = C562CMS x C309. 1913-#,1915-# = C918. 1913-#(S₁) = selected S₁ families.

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(cont.)

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Score
Set 3:	B794-3 (16 varieties x 8 reps, RCB)							
3911-1H20	87-309H3 x RZM 0911-1	6996	26.50	13.2	1.6	135	93.8	162
3915-23H20	87-309H3 x RZM 0915-23	6544	25.02	13.1	0.0	131	91.7	123
3911-4(B)H20	87-309H3 x RZM 0911-4(B)	6454	23.99	13.4	0.6	131	92.0	131
3915-4H20	87-309H3 x RZM 2915-4	6353	24.10	13.2	0.0	136	89.7	93
3915-1H20	87-309H3 x RZM 0915-1	6290	24.83	12.5	0.4	140	91.6	135
3915-6H20	87-309H3 x RZM 0915-6	6149	24.39	12.7	0.0	131	93.3	143
3913-6H20	87-309H3 x RZM 0913-6	6085	23.78	12.7	0.0	140	92.0	101
3915-22H20	87-309H3 x RZM 0915-22	5991	23.60	12.8	0.0	136	90.8	126
3915-16H20	87-309H3 x RZM 0915-16	5882	23.41	12.5	0.0	140	92.5	127
3915-24H20	87-309H3 x RZM 0915-24	5876	23.44	12.5	0.0	139	91.0	139
3915-27H20	87-309H3 x RZM 0915-27	5757	23.77	12.1	3.8	145	92.5	154
3915-46H20	87-309H3 x RZM 2915-46	5419	21.10	12.9	0.0	124	92.1	91
3915-34H20	87-309H3 x RZM 0915-34	5377	22.14	12.1	0.5	132	91.1	98
3913-9H20	87-309H3 x RZM 2913-9	5259	21.41	12.1	0.0	140	88.4	82
3911-24H20	87-309H3 x RZM 2911-24	5126	20.41	12.4	0.0	136	91.1	124
3915-7H20	87-309H3 x RZM 2915-7	4836	19.45	12.5	0.0	134	89.5	75
Mean		5899.6	23.21	12.7	0.4	135.5	91.5	119.0
LSD (.05)		982.4	3.38	1.0	1.4	12.7	3.0	63.2
C.V. (%)		16.8	14.70	8.2	339.0	9.4	3.3	53.6
F value		2.7**	2.35*	1.2NS	3.7**	1.2NS	1.7NS	1.3NS

Note: See footnote for Test B694.
[1]87-309H3 = C562CMS x C309. RZM 0911-#, 0913-#, 0915-# = reselected HS families.

TEST B894. EVALUATION/SELECTION OF BREEDING LINES FOR RESISTANCE TO RHIZOMANIA AND/OR HIGH TEMPERATURE, 1993-94

Planted: September 28, 1993
Not harvested for yield

96 entries x 4 replications (systematic)
1-row plots, 7 + 2 ft. long, 48 blocks

Variety	Description	Stand Count No.	Bolting %	Appear. Score[1] 6/30/94	% Dead[2] (Rotted) 6/30/94	% Dead[2] (Rotted) 7/07/94	% Surv[2] 06/30	% Surv[2] 07/07
Checks								
US H11	L113401	10.5	0.0	4.0	72.1	83.8	27.9	16.2
HH 41	L412307	10.3	0.0	4.3	70.6	89.4	29.4	10.6
Rhizoguard	L893301	10.5	2.3	2.8	33.8	49.9	66.2	50.1
Rizor	RZ3/1022	9.8	0.0	2.5	10.8	45.2	89.2	54.8
O.P.,MM Checks								
Y339	YR-ER-PMR Y139, (C39)	11.5	0.0	2.0	24.1	44.1	75.9	55.9
R039C5	Inc. R939C5, (C39R)	9.0	5.6	2.5	-0.3	33.7	100.3	66.3
R139C7	RZM R039C6	10.5	4.8	1.8	23.9	42.5	76.1	57.5
U86-37	Inc. C37 (86443)	10.0	0.0	3.3	51.3	71.4	48.8	28.6
Y347	YR-ER-PMR Y147, (C47)	10.8	3.1	2.3	23.3	59.3	76.7	40.7
R147C7	RZM R047C6, (C47R)	11.8	0.0	3.0	25.7	62.8	74.3	37.2
Y231-43	Inc. Y131-43, (C31-43)	12.0	0.0	3.8	62.7	78.9	37.3	21.1
Y231-89	Inc. Y131-89, (C31-89)	11.0	0.0	4.5	74.3	81.1	25.7	18.9
mm Checks								
F92-790-15CMS	CMS x C790-15	11.3	0.0	4.3	55.2	81.3	44.8	18.7
F92-790-15H26	C309CMS x C790-15	9.5	0.0	3.8	41.0	73.3	59.0	26.7
F92-790-15H39	C762-17CMS x C790-15	10.3	0.0	4.3	55.2	77.1	44.8	22.9
F92-790-15H97	C796-43CMS x C790-15	10.3	0.0	4.5	84.1	92.5	15.9	7.5
R22 Lines								
R722	Inc.F_2(Y54 x B.m.),(C50)	11.0	36.6	2.8	38.4	59.5	61.6	40.5
R122R3	RZM R022R2	11.5	25.1	2.3	32.0	55.4	68.0	44.6
R222R4	RZM R122R3	11.8	31.9	2.3	29.5	55.8	70.5	44.2
R322R4(%)	RZM R122R3 (%S)	10.3	43.1	2.0	7.3	34.0	92.7	66.0
R322R4	RZM R122R3 (GSY)	11.5	36.7	2.0	18.6	51.3	81.4	48.7
R322Y3(%)	YR-ER-PMR R122Y2 (%S)	8.8	22.9	1.5	19.4	43.1	80.6	56.9
R322Y3	YR-ER-PMR R122Y2 (GSY)	11.5	4.8	2.5	34.9	63.4	65.1	36.6
R336	RZM 2243-#(C)	9.3	0.0	2.8	21.2	45.5	78.8	54.5

TEST B894. EVALUATION/SELECTION OF BREEDING LINES FOR RESISTANCE TO RHIZOMANIA AND/OR HIGH TEMPERATURE, 1993-94

(cont.)

Variety	Description	Stand Count No.	Bolting %	Appear. Score[1] 6/30/94	% Dead[2] (Rotted) 6/30/94	% Dead[2] (Rotted) 7/07/94	% Surv[2] 06/30	% Surv[2] 07/07
C37 Background (R04 Source)								
3201	U86-37 x RZM 2201	9.5	3.1	3.5	49.4	75.6	50.6	24.4
3201P	RZM 2201 x U86-37	10.8	4.4	2.8	35.3	69.2	64.7	30.8
R332	RZM 2201-#(C)	11.8	22.3	3.0	24.7	59.8	75.3	40.2
R332R	RZM R232	12.0	24.9	2.5	28.9	52.1	71.1	47.9
PI 07 Source								
3202	U86-37 x RZM 2202	10.0	0.0	3.0	32.8	54.7	67.2	45.3
R328	RZM 2202-#(C)	10.5	0.0	3.0	27.1	53.5	72.9	46.5
R328R2	RZM R228, (C28)	11.5	0.0	3.3	34.5	63.1	65.5	36.9
R329	RZM 2206-#(C)	10.8	2.5	3.5	45.9	71.7	54.1	28.3
R05 (Italian) Source								
3245	U86-37 x RZM 2245	10.8	0.0	2.8	34.2	67.1	65.8	32.9
3245P	RZM 2245 x U86-37	11.8	0.0	2.3	22.7	49.7	77.3	50.3
R334	RZM 2245-#(C)	10.0	0.0	2.5	26.1	52.5	73.9	47.5
R309	RZM R209-#(C)	9.8	2.3	3.0	44.8	61.4	55.2	38.6
R22 (B.maritima) Source								
3243	U86-37 x RZM 2243	11.0	4.2	2.5	29.2	52.1	70.8	47.9
3243P	RZM 2243 x U86-37	10.8	0.0	2.5	23.4	53.6	76.6	46.4
WB151 (%S) Source								
3247	U86-37 x RZM 2247	10.8	3.6	3.0	27.4	51.1	72.6	48.9
3247P	RZM 2247 x U86-37	9.5	0.0	3.3	23.1	47.7	76.9	52.3
R337	RZM 2247-#(C)	12.0	11.4	2.8	34.7	54.7	65.3	45.3
Rima Source								
R335	RZM 2242-#(C)	10.0	4.5	3.0	24.7	66.2	75.3	33.8
WB169 Source								
3248	U86-37 x RZM EDW-I	11.8	8.8	2.5	32.6	55.2	67.4	44.8
3248P	RZM EDW-I x U86-37	10.5	4.5	2.3	28.3	48.7	71.7	51.3

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TEST B894. EVALUATION/SELECTION OF BREEDING LINES FOR RESISTANCE TO RHIZOMANIA AND/OR HIGH TEMPERATURE, 1993-94

(cont.)

Variety	Description	Stand Count No.	Bolting %	Appear. Score[1] 6/30/94	% Dead[2] (Rotted) 6/30/94	% Dead[2] (Rotted) 7/07/94	% Surv[2] 06/30	% Surv[2] 07/07
WB258 Source								
3249	U86-37 x RZM EDW-II	10.5	11.9	2.3	19.3	44.3	80.7	55.7
3249P	RZM EDW-II x U86-37	12.3	7.2	2.5	27.5	49.7	72.5	50.3
WB41 Source								
3250	U86-37 x RO24	11.3	0.0	3.5	46.6	67.4	53.4	32.6
3250P	RO24 x U86-37	9.5	2.8	3.0	29.9	54.2	70.1	45.8
WB42 Source								
3251	U86-37 x RO25	11.5	2.1	2.5	37.2	47.7	62.8	52.3
3251P	RO25 x U86-37	11.0	2.1	2.3	24.1	46.9	75.9	53.1
915aa x R22 Source								
3287	2915aa x 2243	9.8	0.0	2.3	28.9	51.4	71.1	48.6
C37Rz								
R379	RZM R279,R279Y,R279R2	10.0	14.9	3.3	39.0	63.0	61.0	37.0
Composite C37 Background								
R338-1	RZM R279R2 x C (Rz)	11.0	9.3	2.3	27.9	50.8	72.1	49.2
R338-2	RZM R279(Iso) x C (Rz)	10.3	7.7	2.8	31.5	56.0	68.5	44.0
R338-3	RZM R279Y(Iso) x C (Rz)	9.5	5.3	3.0	26.1	55.0	73.9	45.0
R338-4	R221 x C (WB42)	10.3	10.4	2.0	17.9	47.7	82.1	52.3
R338-5	RZM 2201-#(C)x C(RO4)	10.5	17.1	3.3	41.6	63.7	58.4	36.3
R338-7	RZM 2202-#(C)x C(PI07)	8.8	13.8	2.5	28.7	50.4	71.3	49.6
R338-9	RZM 2242-#(C)x C(Rima)	11.0	0.0	2.5	12.9	51.9	87.1	48.1
R338-11	RZM 2245-#(C)x C(RO5)	9.5	12.5	2.8	16.7	33.8	83.3	66.3
R338-13	RZM 2245-#(C)x C(R22)	9.5	2.8	2.5	21.9	46.5	78.1	53.5
R338-15	RZM 2247-#(C)xC(WB151)	10.0	14.9	2.8	26.3	53.9	73.7	46.1

TEST B894. EVALUATION/SELECTION OF BREEDING LINES FOR RESISTANCE TO RHIZOMANIA
AND/OR HIGH TEMPERATURE, 1993-94

(cont.)

Variety	Description	Stand Count No.	Bolting %	Appear. Score[1] 6/30/94	% Dead[2] (Rotted) 6/30/94	% Dead[2] (Rotted) 7/07/94	% Surv[2] 06/30	% Surv[2] 07/07
Rz Source								
R383	Composite rr x R283R	9.5	2.3	3.3	32.2	69.6	67.8	30.4
R384	Inc. R176-43; -89-#	9.5	0.0	3.5	43.8	70.7	56.3	29.3
R380 (Iso)	RZM R280 (Iso)	11.3	0.0	2.3	12.9	42.5	87.1	57.5
R380Y (Iso)	RZM R280Y	10.3	0.0	2.3	12.4	37.6	87.6	62.4
R378 (Iso)	RZM R278 (Iso)	10.8	1.9	2.3	14.6	49.6	85.4	50.4
R378Y (Iso)	RZM R278Y	11.3	5.0	2.5	25.7	48.1	74.3	51.9
R370	RZM R270Y	10.0	0.0	2.3	23.8	44.9	76.2	55.1
R376 (Iso)	RZM R276 (Iso)	8.8	15.8	2.8	25.3	60.8	74.7	39.2
R376Y (Iso)	RZM R276Y (Iso)	8.5	0.0	2.8	16.0	47.1	84.0	52.9
R376-43 (Iso)	RZM R276-43	10.3	2.8	3.3	27.5	60.8	72.5	39.2
R376-43-14	Inc. R176-43-14	10.8	0.0	3.0	36.7	68.7	63.3	31.3
R376-43-15	Inc. R176-43-15	11.0	0.0	2.5	27.8	56.3	72.2	43.7
R376-43-#(C)	Inc.R176-43-#(C),(C76-43)	10.3	0.0	3.3	56.7	74.0	43.3	26.0
R381-43 (Iso)	RZM R281-43	9.5	7.6	2.8	33.5	53.5	66.5	46.5
R376-89 (Iso)	RZM R276-89	11.8	1.9	2.8	35.9	57.1	64.1	42.9
R376-89-5	Inc. R176-89-5	11.3	0.0	3.3	47.9	64.8	52.1	35.2
R376-89-18	Inc. R176-89-18	10.5	0.0	3.3	37.0	54.5	63.0	45.5
R376-89-#(C)	Inc.R176-89-#(C),(C76-89)	10.0	0.0	3.3	35.0	64.9	65.0	35.1
R381-89	RZM R281-89	11.0	0.0	2.3	8.9	42.5	91.1	57.5
R384	Inc. R176-43;-89-#	10.3	2.3	3.0	43.5	62.4	56.5	37.6
Z325	RZM Z120,...,Z124	13.0	5.7	3.0	25.0	61.3	75.0	38.7
Z330	RZM Z230	9.5	9.4	3.3	28.4	67.8	71.6	32.2

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TEST B894. EVALUATION/SELECTION OF BREEDING LINES FOR RESISTANCE TO RHIZOMANIA AND/OR HIGH TEMPERATURE, 1993-94

(cont.)

Variety	Description	Stand Count No.	Bolting %	Appear. Score[1] 6/30/94	% Dead[2] (Rotted) 6/30/94	% Dead[2] (Rotted) 7/07/94	% Surv[2] 06/30	% Surv[2] 07/07
Nematode Resistant								
N152	NR-RZM 0204-2(C)	11.5	0.0	3.3	47.5	69.3	52.5	30.7
N244	NR-RZM N144-#-#(C)	11.3	0.0	3.5	40.3	64.8	59.7	35.2
N354	NR-RZM N254-#-#(C)	9.5	8.1	3.5	43.7	59.5	56.3	40.5
N203H15	1915aa x N103,N103-1,(C603)	9.8	3.1	4.0	56.9	82.4	43.1	17.6
S^f,MM,Rz,A:aa								
3915(Sp)	2915,...,2911aa x A	10.5	7.0	2.8	16.0	45.2	84.0	54.8
3918(Sp)	1913-S_l;1915-$S_l$aa x A,(C918)	10.0	2.8	2.8	24.6	43.9	75.4	56.1
3918-#(C)	Inc. 1913-S_l, 1915-S_l	10.0	4.5	2.5	34.0	75.3	66.0	24.7
3916	RZM 2916	11.5	0.0	3.0	42.9	64.7	57.1	35.3
3893m	Composite mmaa x mm,O-T	10.3	0.0	3.3	47.8	67.0	52.2	33.0
3894m	Mother root(C)mmaa x A	11.3	0.0	3.5	30.8	50.5	69.2	49.5
3867m(Sp)	2867mmaa x A	10.0	0.0	3.0	22.3	43.5	77.7	56.5
3890	0790mmaa x 2890 (C890)	10.0	0.0	4.3	66.2	81.1	33.8	18.9
Mean		10.5	5.5	2.9	33.0	58.1	67.0	41.9
LSD (.05)		2.6	10.1	0.9	24.8	21.0	24.8	21.0
C.V. (%)		17.9	131.8	21.7	54.0	26.0	26.6	36.1
F value		0.9NS	6.0**	3.8**	2.9**	2.8**	2.9**	2.8**

Notes: Tests B894 and B994 were planted into an area with moderate but variable rhizomania infestation. The purposes of these trials were to observe plant type and uniformity and to assess survivability under late season high temperature conditions in which rhizomania infestation was known. The cultural practices were the same as for tests B694 and B794 harvested in May for yield, except these tests were watered three additional times on 5/24, 6/8, and 6/21/94. Temperatures in late June were hot with daytime maximums approaching 120 F and nighttime lows of 86-90 F. The cause of plant death and rotting, other than rhizomania, was not determined. By July 1, the plants in many plots had collapsed or were in a state of rapid decline. In general, the best survivability was associated with resistance to rhizomania, particularly from some of the wild beet sources. Observations suggested that there were sufficient genetic differences to make rapid progress in survivability under these conditions.

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TEST B894. EVALUATION/SELECTION OF BREEDING LINES FOR RESISTANCE TO RHIZOMANIA AND/OR HIGH TEMPERATURE, 1993-94

(cont.)

Variety	Description	Stand Count No.	Bolting %	Appear. Score[1] 6/30/94	% Dead[2] (Rotted) 6/30/94	% Dead[2] (Rotted) 7/07/94	% Surv[2] 06/30	% Surv[2] 07/07
								07/07

Notes (cont.): Survivability counts were made based upon top appearance and not visually observed root rot. Living plants were those with 4 to 6 surviving leaves.

[1]Appearance scores of canopy were made 6/30/94 on a scale of 1 to 5, where 1 was best and 5 was poorest. These subjective scores were made based upon survivability, vigor, color, and general appearance.

[2]Calculated from differences between stand counts post thinning and living plant counts on 6/30/94 and 7/7/94. Final weeks of season were very hot with daytime temperatures greater than 110 F.

TEST B594. EFFECTS OF SOIL TREATMENTS BY VARIETIES TO CONTROL RHIZOMANIA
IN IMPERIAL VALLEY, BRAWLEY, CA., 1993-94

4 varieties x 4 soil trtmts x 4 reps., Split-Split-Plot
1-row plots, 30 ft. long

Planted: October 15, 1993
Harvested: May 21 & July 1, 1994

Treatment	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harvest Count No.	Clean Beets %	NO3-N Mean	Root Rot %
Soil Treatments (S)								
1. Control	2260	7.99	13.52	47	31	90.6	97.41	34.7
2. Solarization	9636	29.52	16.37	52	50	95.8	56.06	2.3
3. Vapam	2676	9.49	13.66	48	36	93.1	70.20	26.0
4. Methylbromide	10386	33.22	15.75	53	52	94.8	65.85	0.6
Varieties (V)								
1. HH41	5941	19.49	13.68	51	40	93.2	65.86	21.1
2. Rhizoguard	6189	19.20	15.55	49	43	95.6	57.76	12.7
3. R378H52	6654	21.43	15.28	50	43	93.8	75.71	13.9
4. R338H52	6174	20.10	14.80	50	43	91.8	90.20	15.9
Harvest Date (H)								
1. May 21, 1994	6623	20.22	15.88	50	48	94.0	41.69	4.0
2. July 1, 1994	5856	19.89	13.77	50	37	93.1	103.08	27.8
S x V								
1 x 1	1588	6.24	11.02	48	25	90.5	74.69	45.7
1 x 2	2616	8.75	14.70	47	34	93.6	63.88	29.1
1 x 3	2578	8.70	14.65	48	35	89.9	88.66	28.3
1 x 4	2257	8.27	13.71	46	30	88.6	162.44	35.6
2 x 1	9486	29.47	16.08	52	49	95.4	54.81	5.7
2 x 2	9332	27.65	16.93	51	50	98.0	43.75	1.1
2 x 3	10292	31.89	16.18	52	50	95.8	72.13	3.2
2 x 4	9435	29.09	16.30	52	52	94.2	53.56	-0.7
3 x 1	1937	7.76	11.96	50	33	91.3	65.50	34.0
3 x 2	2816	9.60	14.20	47	39	95.0	63.56	20.3
3 x 3	3095	10.21	14.90	46	36	94.5	68.19	23.2
3 x 4	2856	10.39	13.60	49	36	91.5	83.56	26.3
4 x 1	10752	34.52	15.67	54	54	95.5	68.43	-1.2
4 x 2	9991	30.79	16.38	50	50	95.8	59.84	0.2
4 x 3	10651	34.92	15.38	53	53	95.0	73.88	0.7
4 x 4	10149	32.65	15.58	53	51	92.7	61.25	2.5

TEST B594. EFFECTS OF SOIL TREATMENTS BY VARIETIES TO CONTROL RHIZOMANIA IN IMPERIAL VALLEY, BRAWLEY, CA., 1993-94
(cont.)

Treatment	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Stand Count No.	Harvest Count No.	Clean Beets %	NO3-N Mean	Root Rot %
S x H								
1 x 1	2826	9.60	14.61	47	41	90.9	69.92	13.0
1 x 2	1694	6.38	12.43	47	21	90.4	124.91	56.4
2 x 1	9932	29.06	17.14	52	51	96.3	38.03	1.8
2 x 2	9341	29.99	15.60	52	50	95.4	74.09	2.8
3 x 1	3429	11.30	15.08	48	47	93.1	32.78	2.6
3 x 2	1923	7.68	12.25	48	25	93.1	107.63	49.3
4 x 1	10304	30.93	16.70	52	53	95.9	26.01	-1.6
4 x 2	10468	35.51	14.81	53	51	93.6	105.69	2.7
V x H								
1 x 1	6539	20.60	14.94	50	48	93.3	33.37	6.0
1 x 2	5343	18.39	12.42	51	33	93.1	98.34	36.1
2 x 1	6468	19.03	16.57	49	49	96.0	27.11	0.8
2 x 2	5910	19.36	14.53	48	37	95.2	88.41	24.5
3 x 1	7043	21.27	16.37	49	47	94.8	50.27	4.3
3 x 2	6266	21.59	14.18	50	40	92.9	101.16	23.5
4 x 1	6441	19.99	15.64	51	48	92.1	56.00	4.7
4 x 2	5907	20.22	13.96	49	37	91.4	124.41	27.2
S x V x H								
1 x 1 x 1	2508	9.14	13.52	46	38	90.5	54.38	16.4
1 x 1 x 2	669	3.35	8.52	50	12	90.5	95.00	75.1
1 x 2 x 1	3196	10.39	15.43	47	43	94.0	37.75	9.9
1 x 2 x 2	2037	7.12	13.98	47	25	93.2	90.00	48.3
1 x 3 x 1	2987	9.63	15.49	48	42	91.2	61.44	12.3
1 x 3 x 2	2169	7.76	13.81	48	27	88.6	115.88	44.4
1 x 4 x 1	2613	9.25	14.03	48	42	87.8	126.13	13.3
1 x 4 x 2	1900	7.29	13.40	44	18	89.4	198.75	57.9
2 x 1 x 1	10085	30.06	16.80	53	50	95.3	23.25	4.8
2 x 1 x 2	8888	28.87	15.36	52	48	95.4	86.38	6.7
2 x 2 x 1	9574	27.27	17.60	50	49	98.1	23.13	1.3
2 x 2 x 2	9091	28.03	16.26	51	51	97.9	64.38	0.8
2 x 3 x 1	10599	31.08	17.09	50	50	96.6	73.88	1.5
2 x 3 x 2	9986	32.69	15.27	54	51	95.1	70.38	4.9
2 x 4 x 1	9471	27.82	17.06	54	54	95.2	31.88	-0.3
2 x 4 x 2	9398	30.36	15.54	50	51	93.2	75.25	-1.1

TEST B594. EFFECTS OF SOIL TREATMENTS BY VARIETIES TO CONTROL RHIZOMANIA
IN IMPERIAL VALLEY, BRAWLEY, CA., 1993-94

(cont.)

Treatment (cont.) S x V x H	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harvest Count No.	Clean Beets %	NO_3-N Mean	Root Rot %
3 x 1 x 1	2760	10.63	12.86	49	48	90.7	31.25	2.5
3 x 1 x 2	1115	4.88	11.06	51	18	91.9	99.75	65.5
3 x 2 x 1	3467	10.85	15.81	48	49	94.7	31.38	-0.1
3 x 2 x 2	2165	8.36	12.58	46	29	95.4	95.75	40.8
3 x 3 x 1	3943	12.09	16.39	45	43	95.4	31.50	5.7
3 x 3 x 2	2247	8.33	13.40	47	29	93.6	104.88	40.8
3 x 4 x 1	3546	11.64	15.24	50	49	91.7	37.00	2.3
3 x 4 x 2	2165	9.15	11.96	48	24	91.4	130.13	50.3
4 x 1 x 1	10802	32.58	16.60	54	54	96.6	24.60	0.3
4 x 1 x 2	10702	36.45	14.74	54	55	94.3	112.25	-2.7
4 x 2 x 1	9636	27.62	17.45	51	55	97.4	16.18	-7.7
4 x 2 x 2	10347	33.95	15.31	50	45	94.3	103.50	8.2
4 x 3 x 1	10642	32.27	16.52	54	55	95.8	34.25	-2.4
4 x 3 x 2	10661	37.57	14.25	53	51	94.2	113.52	3.8
4 x 4 x 1	10135	31.23	16.23	51	49	93.7	29.00	3.5
4 x 4 x 2	10162	34.07	14.94	55	54	91.7	93.50	1.6
Grand Mean	6239.6	20.06	14.83	49.8	42.4	93.6	72.38	15.9
C.V.(%) - S x V x H	11.3	12.64	5.77	9.0	12.4	1.8	43.58	55.6
LSD(.05) - S	591.2	2.04	0.58	4.3	4.6	1.0	21.38	5.9
LSD(.05) - V	591.2	2.04	0.58	4.3	4.6	1.0	21.38	5.9
LSD(.05) - H	**	NS	**	NS	**	**	**	**
LSD(.05) - S x V	1182.0	4.08	1.17	8.6	9.1	1.9	42.75	11.7
LSD(.05) - S x H	499.9	1.80	0.61	3.2	3.7	1.2	22.42	6.3
LSD(.05) - V x H	499.9	1.80	0.61	3.2	3.7	1.2	22.42	6.3
LSD(.05) - S x V x H	999.7	3.60	1.22	6.4	7.5	2.4	44.84	12.6
F value - S	443.0**	337.88**	49.96**	3.1*	42.9**	44.7**	5.57**	68.9**
F value - V	2.1NS	1.91NS	16.23**	0.4NS	0.7NS	22.4**	3.46*	3.2*
F value - H	38.0**	0.55NS	194.31**	0.0NS	148.1**	8.9**	121.24**	233.4**
F value - S x V	0.9NS	0.92NS	4.31**	0.1NS	0.7NS	1.8NS	2.17*	1.1NS
F value - S x H	8.5**	18.64**	3.28*	0.0NS	39.7**	2.5NS	3.21*	61.7**
F value - V x H	1.5NS	1.96NS	1.35NS	0.6NS	1.9NS	1.4NS	0.46NS	2.1NS
F value - S x V x H	0.4NS	0.44NS	3.57**	0.9NS	2.1*	1.0NS	0.68NS	2.3*

EFFECTS OF SOIL TREATMENTS BY VARIETIES TO CONTROL RHIZOMANIA IN IMPERIAL VALLEY, BRAWLEY, CA., 1993-94

(cont.)

Treatment	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value	Known Sugar/Loss lbs/a	Recover. Sugar lbs/a	Recover. Sugar %	Recover. Sugar lbs/t
Soil Treatments (S)								
1. Control	1180	2213	164	11219	257	1971	84.3	231
2. Solarization	390	1786	239	8099	720	8916	92.5	303
3. Vapam	927	1864	179	9602	271	2405	89.1	244
4. Methylbromide	351	2142	342	9835	983	9403	90.6	286
Varieties (V)								
1. HH41	908	2036	210	10259	538	5403	86.3	243
2. Rhizoguard	651	1850	226	9052	514	5675	91.1	284
3. R378H52	651	2110	224	9685	604	6050	90.4	276
4. R338H52	638	2010	263	9759	576	5567	88.7	261
Harvest Date (H)								
1. May 21, 1994	591	2197	250	9936	582	6040	90.4	288
2. July 1, 1994	833	1805	212	9442	533	5307	87.9	244
S x V								
1 x 1	1543	2439	112	12565	210	1379	76.0	183
1 x 2	963	1907	160	9656	252	2364	90.1	265
1 x 3	1124	2345	184	11547	288	2289	88.1	258
1 x 4	1090	2163	198	11108	280	1852	83.1	216
2 x 1	427	1726	211	7810	687	8799	92.7	298
2 x 2	385	1777	272	8377	703	8629	92.6	313
2 x 3	401	1913	221	8281	788	9504	92.3	299
2 x 4	346	1728	253	7929	703	8732	92.6	302
3 x 1	1304	1928	172	11016	259	1678	85.8	206
3 x 2	926	1725	145	8930	245	2571	90.2	257
3 x 3	700	1883	180	8863	273	2822	91.0	271
3 x 4	778	1918	219	9598	306	2549	89.2	243
4 x 1	356	2049	345	9646	994	9757	90.8	284
4 x 2	330	1989	328	9247	854	9137	91.5	300
4 x 3	379	2299	313	10047	1068	9583	90.1	277
4 x 4	338	2230	384	10401	1015	9134	90.0	280

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TEST B594. EFFECTS OF SOIL TREATMENTS BY VARIETIES TO CONTROL RHIZOMANIA IN IMPERIAL VALLEY, BRAWLEY, CA., 1993-94
(cont.)

Treatment (cont.)	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value	Known Sugar/Loss lbs/a	Recover. Sugar lbs/a	Recover. Sugar %	Recover. Sugar lbs/t
S x H								
1 x 1	1023	2360	174	11137	312	2514	88.4	259
1 x 2	1337	2066	153	11301	203	1429	80.2	202
2 x 1	270	1990	248	8276	728	9204	92.7	318
2 x 2	510	1582	230	7923	713	8628	92.4	288
3 x 1	799	2048	235	10150	339	3091	89.6	271
3 x 2	1055	1679	122	9054	203	1720	88.6	218
4 x 1	273	2390	342	10180	951	9353	90.8	303
4 x 2	428	1894	343	9491	1014	9453	90.3	268
V x H								
1 x 1	744	2195	232	10292	591	5948	89.2	268
1 x 2	1072	1876	188	10227	484	4859	83.4	218
2 x 1	533	2020	225	9050	512	5956	91.7	304
2 x 2	769	1679	228	9054	515	5395	90.4	263
3 x 1	528	2301	257	10038	629	6414	90.7	297
3 x 2	774	1919	192	9331	580	5686	90.0	256
4 x 1	560	2271	287	10363	598	5843	89.8	282
4 x 2	715	1748	240	9156	554	5290	87.7	239
S x V x H								
1 x 1 x 1	1238	2311	108	11133	284	2224	87.5	237
1 x 1 x 2	1848	2567	117	13997	136	534	64.4	128
1 x 2 x 1	864	2050	153	9602	298	2898	90.5	280
1 x 2 x 2	1061	1763	167	9711	206	1831	89.6	250
1 x 3 x 1	884	2418	221	11239	321	2666	89.1	276
1 x 3 x 2	1364	2273	147	11855	255	1913	87.1	241
1 x 4 x 1	1104	2663	216	12574	346	2267	86.4	243
1 x 4 x 2	1077	1663	181	9642	213	1437	79.9	190
2 x 1 x 1	284	1916	232	7983	724	9361	92.8	312
2 x 1 x 2	571	1536	189	7638	650	8238	92.5	284
2 x 2 x 1	275	1905	287	8456	704	8870	92.8	327
2 x 2 x 2	496	1650	257	8298	703	8388	92.3	300
2 x 3 x 1	304	2280	214	8800	820	9778	92.2	315
2 x 3 x 2	498	1546	227	7762	756	9230	92.3	282
2 x 4 x 1	217	1859	259	7864	664	8808	93.0	318
2 x 4 x 2	474	1597	247	7994	742	8656	92.2	287

TEST B594. EFFECTS OF SOIL TREATMENTS BY VARIETIES TO CONTROL RHIZOMANIA IN IMPERIAL VALLEY, BRAWLEY, CA., 1993-94

(cont.)

S x V x H (cont.)	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value	Known Sugar/Loss lbs/a	Recover. Sugar lbs/a	Recover. Sugar %	Recover. Sugar lbs/t
3 x 1 x 1	1163	2211	247	11945	374	2386	85.6	221
3 x 1 x 2	1446	1646	96	10087	145	970	86.0	191
3 x 2 x 1	757	1908	156	8897	280	3187	91.5	290
3 x 2 x 2	1096	1543	134	8962	210	1955	89.0	225
3 x 3 x 1	629	2036	253	9692	346	3598	91.1	299
3 x 3 x 2	771	1729	107	8035	200	2047	91.0	244
3 x 4 x 1	647	2036	285	10066	354	3192	90.1	275
3 x 4 x 2	908	1799	153	9130	259	1906	88.4	212
4 x 1 x 1	289	2344	340	10107	982	9820	90.9	302
4 x 1 x 2	422	1754	350	9186	1007	9695	90.6	267
4 x 2 x 1	236	2217	303	9246	767	8869	92.0	321
4 x 2 x 2	424	1762	354	9247	941	9406	90.9	278
4 x 3 x 1	295	2469	338	10421	1028	9615	90.5	299
4 x 3 x 2	463	2128	288	9674	1109	9552	89.7	256
4 x 4 x 1	273	2528	386	10947	1028	9106	89.9	292
4 x 4 x 2	402	1933	381	9856	1001	9162	90.1	269
Grand Mean	711.8	2001.2	231.0	9688.9	557.9	5673.9	89.1	265.9
C.V. (%)	24.9	15.4	33.7	14.6	19.6	11.8	7.1	9.1
LSD (.05) - S	119.4	187.6	43.8	981.8	98.2	536.1	3.5	16.9
LSD (.05) - V	119.4	187.6	43.8	981.8	98.2	536.1	3.5	16.9
LSD (.05) - H	**	**	**	*	**	**	*	**
LSD (.05) - S x V	238.9	375.1	87.7	1964.0	196.4	1072.0	7.1	33.7
LSD (.05) - S x H	125.9	219.5	55.4	1008.0	77.8	476.1	4.5	17.2
LSD (.05) - V x H	125.9	219.5	55.4	1008.0	77.8	476.1	4.5	17.2
LSD (.05) - S x V x H	251.8	439.1	110.8	2016.0	155.5	952.2	9.0	34.4
F value - S	94.7**	10.0**	27.8**	13.7**	106.5**	459.4**	8.0**	33.1**
F value - V	9.7**	2.8**	2.2NS	2.1NS	1.4NS	2.1NS	2.9*	9.5**
F value - H	59.4**	51.4**	7.6**	3.9*	6.5**	38.3**	5.1*	104.7**
F value - S x V	3.3**	0.9NS	0.7NS	1.3NS	0.4NS	1.0NS	1.5NS	2.6*
F value - S x H	1.1NS	0.6NS	3.4*	1.1NS	5.5**	7.4**	2.9*	2.4**
F value - V x H	1.3NS	0.7NS	1.1NS	1.3NS	1.3NS	1.1NS	1.1NS	0.3NS
F value - S x V x H	1.5NS	2.3*	0.5NS	1.9NS	0.6NS	0.3NS	1.4NS	1.8**

TEST B594. EFFECTS OF SOIL TREATMENTS BY VARIETIES TO CONTROL RHIZOMANIA IN IMPERIAL VALLEY, BRAWLEY, CA., 1993-94

(cont.)

NOTES:

Test B594 was established in a field plot area with known severed rhizomania. In addition, cyst nematode may have been important. After this area was identified as having a trace of rhizomania in 1989, beet trials were grown and, harvested in 1992 and 1993 to evaluate the effects of rhizomania in the Imperial Valley. thus in addition to rhizomania and cyst nematode, any soil problem increased by conservative beet crops could have influenced performance. Solarization and fumigation treatments would not specifically target _Polymyxa betae_, the vector of BNYVV (rhizomania) but could possibly control a broad spectrum of biotic soil factors, including weeds. The factor(s) for resistance to rhizomania in Rhizoguard, R378H52, and R338H52 would be effective only against BNYVV (rhizomania).

HH41 and Rhizoguard are Holly commercial hybrids. R378H52 and R338H52 are USDA experimental hybrids: R378H52 = (C762-17CMS x C790-15) x R78; R338H52 = (C762-17CMS x C790-15) x R38. R38 = composite of sources of resistance to rhizomania in a C37 background. R78 has the Rz gene.

% root rot was calculated as the difference between the stand count and harvest count divided by the stand count. Thus negative numbers occur when there were more beets harvested than counted post thinning. At harvest, every beet no matter how small was counted. Thus doubles and late emergers could have increased harvest counts and decreased the apparent frequency of dead (rotted) plants. Partially rotted plants were counted as living and included in the harvest.

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TEST 3294.   CBGA/BSDF CODED RHIZOMANIA VARIETY TRAIL, SPENCE BLOCK 2N (SEVERE), SALINAS, CA., 1994

Planted: April 20, 1994
Harvested: October 19, 1994

64 entries x 4 replications, RCB
1-row plots, 20 ft. long

| Variety Code | Variety Name[1] | Company | Acre Yield | | Sucrose | Beets/ 100' | Bolting | RJAP |
			Sugar Lbs	Beets Tons	%	No.	%	%
57	2J6333	Betaseed	9628	27.72	17.38	203	0.0	85.8
58	2J6335	Betaseed	9430	27.71	17.05	209	0.0	85.2
56	2J6309	Betaseed	8944	27.41	16.35	203	0.0	85.4
19	93HX29	Holly	8340	26.15	15.95	190	0.0	81.9
54	3J0159	Betaseed	8283	25.29	16.38	181	0.0	84.7
31	2J0152	Beta	8120	25.45	16.00	178	0.0	83.9
48	2J5088	Betaseed	8018	25.41	15.85	199	0.0	84.9
43	3J5128	Betaseed	7822	25.10	15.63	194	0.0	83.9
2	HM 3042	Hill-MH	7804	25.31	15.45	201	0.0	85.1
52	93HX13	Holly	7638	24.47	15.60	193	0.0	84.1
59	14605	Betaseed	7617	23.55	16.25	191	0.0	84.6
20	2J0179	Betaseed	7385	22.47	16.40	186	0.0	84.5
55	3J5059	Betaseed	7292	22.01	16.60	179	0.0	83.2
8	Beta 4581	Betaseed	7288	22.68	16.05	191	0.0	83.7
23	90-1459-0188	Holly	7273	23.17	15.77	165	0.0	82.3
5	93HX15	Holly	7267	23.94	15.38	186	0.0	85.5
11	SS-NB2R2	Spreckels	7234	22.46	16.10	185	0.0	83.4
53	Rhizosen	Holly	7050	22.85	15.48	205	0.0	85.0
28	HM 3041	Hill-MH	6946	23.00	15.15	208	0.0	85.4
37	93HX14	Holly	6932	22.68	15.27	193	0.0	85.3
33	94HX24	Holly	6889	21.80	15.82	185	1.3	82.6
26	SS-781R	Spreckels	6857	23.10	14.88	163	0.0	84.7
38	3BG6384	Betaseed	6853	22.05	15.50	193	0.0	83.8
14	94HX25	Holly	6827	21.21	16.15	170	0.0	80.7
36	HH-101R	Holly	6573	21.59	15.23	188	0.0	84.6
9	2J5324	Betaseed	6571	21.03	15.60	161	0.0	85.2
51	SS-NB5R	Spreckels	6562	21.12	15.55	161	0.0	83.8
10	94HX05	Holly	6561	21.38	15.32	188	0.0	83.9
29	93HX25	Holly	6323	20.61	15.35	186	0.0	83.5
16	90C 68-03	Holly	6319	20.51	15.40	185	0.8	83.5

TEST 3294. CBGA/BSDF CODED RHIZOMANIA VARIETY TRAIL, SPENCE BLOCK 2N (SEVERE), SALINAS, CA., 1994

(cont.)

Variety Code	Variety Name[1]	Company	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolting %	RJAP %
7	94HX20	Holly	6230	20.69	15.05	191	0.0	86.2
13	93HX33	Holly	6195	20.48	15.15	189	0.0	82.6
12	90C 68-04	Holly	6169	19.85	15.58	199	0.0	85.6
50	SS-780R	Speckels	6130	20.42	15.00	180	0.0	83.3
22	94HX09	Holly	6078	19.85	15.33	181	0.0	85.3
18	SS-287R	Spreckels	5971	20.27	14.75	196	0.0	82.7
3	93HX35	Holly	5938	20.16	14.77	186	0.0	83.3
40	SS-289R	Spreckels	5896	19.11	15.32	239	0.0	83.1
46	93HX24	Holly	5856	20.06	14.57	186	0.0	83.0
32	Rhizoguard	Holly	5825	19.18	15.23	190	0.0	82.8
41	SS-596R	Spreckels	5790	19.53	14.85	191	0.0	81.9
34	SS-502R	Spreckels	5695	18.38	15.48	203	0.0	82.0
15	Rhizosen CT	Holly	5664	19.02	14.93	194	0.0	85.2
17	2BG6241	Beta	5649	19.53	14.48	204	0.0	86.7
47	Rhizosen Plus	Holly	5607	17.33	16.23	188	0.0	81.8
24	SS-595R	Spreckels	5600	19.62	14.30	191	0.0	83.1
35	93HX34	Holly	5550	18.78	14.80	174	0.0	82.4
42	90-88C11-09	Holly	5486	17.53	15.65	211	0.0	83.7
21	94HX23	Holly	5467	17.96	15.10	154	0.0	84.5
30	SS-NB2R	Spreckels	5362	17.64	15.13	206	0.0	83.7
6	SS-334R	Spreckels	5143	16.49	15.65	188	0.0	82.9
44	94HX22	Holly	5070	15.88	15.93	144	0.0	80.8
4	HH-97R	Holly	5060	19.74	12.80	200	0.0	82.0
49	93HX26	Holly	5008	17.60	14.20	150	0.0	85.2
25	Rhizoguard CT	Holly	4979	17.33	14.40	194	0.0	83.7
1	US H11	Susc. check	4689	18.79	12.52	178	0.0	80.9
27	94HX04	Holly	4597	17.85	12.82	189	0.0	81.7
USDA Entries								
62	Rizor	RZ3/1022 SES	7470	22.16	16.83	206	0.0	82.7
64	N303H15	2915aa x C603-1	7248	25.41	14.38	198	0.0	82.3
63	R338H52	C790-15H39 x R38(C)	5903	20.90	14.20	201	0.0	84.0
61	6770	Susc.check	4762	16.51	14.17	190	0.0	83.8
60	US H11	Susc.check	3876	15.96	12.23	214	0.0	79.8

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TEST 3294. CBGA/BSDF CODED RHIZOMANIA VARIETY TRAIL, SPENCE BLOCK 2N (SEVERE), SALINAS, CA., 1994

(cont.)

Variety Code	Variety Name[1]	Company	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolting %	RJAP %
Mean			6473.0	21.13	15.26	188.9	0.0	83.6
LSD (.05)			1207.6	3.95	0.85	28.5	0.4	3.1
C.V. (%)			13.4	13.42	4.01	10.8	838.4	2.6
F value			7.4**	4.32**	10.23**	2.4**	1.9**	1.9**

[1] USDA entries and checks: US H11 = highly susceptible check with adaptation to northern USA (and Salinas, see tests 894-1094). Rizor = resistant check from SES (Europe). R338H52 = USDA experimental hybrid with rhizomania resistance from many sources in C37 background. N303H15 = popn-915Rzaa x C603 = USDA experimental hybrid with dual resistance to rhizomania and cyst nematode.

Note: This test was designed as a 64 entry x 8 replications test. Entries 1 thru 53 were for CBGA coded rhizomania test. Entries 60 thru 64 were entries and checks added by USDA. Entries 54 thru 59 were from BSDF (Betaseed). Tests 3294 and 4194 involve the same sets of entries. Test 3294 was planted under known severe rhizomania conditions. Test 4194 was planted under unknown rhizomania conditions (first time under rhizomania tests after being infested in 1993). Rhizomania in test 4194 was moderate and fairly uniform. Plant growth was uniform and good. For tests 4294, 4194, 3294 & 3394 gross sugar yield was used as the primary criteria to evaluate differences in resistance to rhizomania; in addition, in tests 4194 and 4294 two replications were hand harvested and scored for rhizomania symptoms. Based uon the known susceptible checks, only about half of the plants expressed fully susceptible symptoms. Thus, escapes were common. In general, if a plant was rated as susceptible, it was susceptible to rhizomania (BNYVV). If a plant was rated as resistant, it may have been resistant or an escape. (Escapes, as far as symptoms on tap roots were concerned, but most likely lateral and feeder roots were infected.) It is still my judgement that gross sugar yield is the best measure of resistance to rhizomania when the relative yield of the entries under nonrhizomania conditions also is known in the area of their adaptation.

Rhizomania was very severe. This was the third sugarbeet crop in rhizomania tests in five years. In addition, cyst nematode was moderate. Root aphids were moderate. Stands were good and the usual problem with seedling loss (Aphanomyces) was not experienced. Nitrogen was applied as if a normal crop, but canopy suggested nitrogen deficiency, probably due to an impaired root system not being able to forage for nitrogen, other nutrients, and water efficiently. Even under moist and cool conditions, plants wilted most afternoons. There was no loss of plants due to root rots.

TEST 4194. CBGA/BSDF CODED RHIZOMANIA VARIETY TRIAL, SPENCE BLOCK 2S (MODERATE), SALINAS, CA., 1994

64 entries x 8 replications, RCB
1-row plots, 20 ft. long

Planted: May 10, 1994
Harvested: October 24-27, 1994

Variety Code	Variety Name[1]	Company	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Powdery Mildew[2] %	RJAP %	RZM Resistance[3] DI	RZM Resistance[3] %Resist.
56	2J6309	Betaseed	10654	33.50	15.91	157	2.1	84.3	2.7	100.0
48	2J5088	Betaseed	10364	33.20	15.62	174	0.3	84.4	2.7	95.8
59	14605	Betaseed	10144	31.95	15.88	146	3.2	84.3	3.0	94.4
58	2J6335	Betaseed	9953	30.77	16.20	164	6.4	83.8	3.0	91.0
57	2J6333	Betaseed	9829	30.08	16.36	163	7.7	83.2	2.9	96.7
43	3J5128	Betaseed	9828	31.23	15.77	161	3.8	84.3	2.9	92.0
55	3J5059	Betaseed	9683	30.29	16.02	148	4.5	82.4	3.1	84.4
20	2J0179	Betaseed	9615	30.19	15.94	146	3.5	83.5	2.8	100.0
19	93HX29	Holly	9558	30.16	15.84	156	5.6	82.7	2.6	98.3
31	2J0152	Betaseed	9514	29.73	16.05	129	2.4	84.5	2.6	100.0
8	Beta 4581	Betaseed	9315	30.43	15.31	156	2.9	82.9	2.8	89.2
54	3J0159	Betaseed	9289	29.99	15.51	142	5.5	83.5	2.8	95.9
37	93HX14	Holly	9100	30.55	14.91	158	5.8	84.0	3.2	86.4
38	3BG6384	Betaseed	9025	29.68	15.23	160	4.0	84.1	2.9	94.3
14	94HX25	Holly	8854	27.85	15.86	134	5.6	82.6	2.7	88.0
2	HM 3042	Hill-MH	8840	29.44	15.01	162	4.3	84.3	3.0	90.6
5	93HX15	Holly	8689	30.24	14.33	166	6.9	83.1	2.9	87.0
39	94HX17	Holly	8597	30.34	14.18	133	4.5	84.2	3.1	82.9
12	90C 68-04	Holly	8578	28.09	15.31	156	5.3	83.8	3.2	82.8
52	93HX13	Holly	8550	28.90	14.79	160	7.0	82.4	3.0	88.5
44	94HX22	Holly	8492	28.31	15.04	127	3.6	82.7	2.9	91.5
28	HM 3041	Hill-MH	8457	28.29	14.95	166	6.1	83.9	2.7	92.5
33	94HX24	Holly	8429	28.37	14.85	146	5.4	82.4	3.0	94.8
26	SS-781R	Spreckels	8399	28.82	14.61	146	4.8	83.2	3.2	85.5
23	90-1459-0188	Holly	8345	27.77	15.04	132	4.8	83.3	2.8	92.1
36	HH-101R	Holly	8335	28.04	14.88	155	4.7	83.5	2.9	90.9
40	SS-289R	Spreckels	8264	27.03	15.33	171	6.9	82.9	3.1	84.9
29	93HX25	Holly	8206	28.30	14.52	138	4.8	83.0	2.9	86.4
9	2J5324	Betaseed	8186	26.88	15.23	136	5.4	83.7	3.9	50.7
51	SS-NB5R	Spreckels	8110	28.30	14.36	137	5.8	84.0	3.1	83.6

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(cont.)

Variety Code	Variety Name[1]	Company	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Powdery Mildew[2] %	RJAP %	RZM Resistance[3] DI	RZM Resistance[3] %Resist.
46	93HX24	Holly	8085	28.05	14.41	146	5.7	83.3	3.2	84.9
11	SS-NB2R2	Spreckels	8047	26.65	15.11	164	6.9	83.8	2.9	88.8
16	90C 68-03	Holly	7935	26.97	14.73	154	5.7	83.6	3.3	79.3
10	94HX05	Holly	7889	26.57	14.86	150	4.3	83.5	3.0	88.6
30	SS-NB2R	Spreckels	7887	27.05	14.59	162	6.2	83.6	3.5	63.6
53	Rhizosen	Holly	7832	26.21	14.95	159	6.1	84.2	2.8	89.2
3	93HX35	Holly	7763	26.83	14.46	151	6.3	83.9	3.3	82.9
17	2BG6241	Betaseed	7723	26.65	14.49	151	1.9	85.5	3.1	82.5
35	93HX34	Holly	7712	26.15	14.74	151	5.3	83.2	3.5	70.9
34	SS-502R	Spreckels	7668	25.58	14.98	151	5.8	83.5	3.6	67.7
24	SS-595R	Spreckels	7606	25.41	14.96	162	5.6	83.2	3.6	71.3
45	SS-293R	Spreckels	7593	26.78	14.19	150	4.3	82.0	3.7	62.1
41	SS-596R	Spreckels	7565	25.39	14.87	156	5.8	83.9	3.0	84.9
7	94HX20	Holly	7512	25.57	14.68	154	5.3	85.5	3.7	57.4
22	94HX09	Holly	7466	25.35	14.71	149	5.3	84.7	3.4	73.5
50	SS-780R	Spreckels	7412	26.24	14.06	156	5.1	84.0	3.0	83.8
18	SS-287R	Spreckels	7411	25.42	14.52	163	5.5	83.7	3.4	74.8
13	93HX33	Holly	7404	25.91	14.28	157	6.4	82.8	3.0	84.1
15	Rhizosen CT	Holly	7344	25.08	14.61	166	3.9	85.8	4.0	59.6
32	Rhizoguard	Holly	7292	24.65	14.76	154	6.4	85.3	2.6	94.7
42	90-88C11-09	Holly	7252	24.13	15.02	152	5.9	83.4	2.9	90.0
47	Rhizosen Plus	Holly	7194	23.75	15.18	151	5.8	83.4	3.2	82.2
21	94HX23	Holly	7181	24.97	14.43	136	3.2	83.5	3.3	76.6
27	94HX04	Holly	7083	25.15	14.07	164	3.9	85.1	3.5	69.1
6	SS-334R	Spreckels	6892	23.04	14.95	146	6.2	81.9	3.1	87.0
4	HH-97R	Holly	6725	23.99	14.03	162	4.3	84.2	4.5	44.2
25	Rhizoguard CT	Holly	6631	23.67	13.99	171	5.6	85.0	3.2	79.1
49	93HX26	Holly	6349	22.93	13.81	141	5.5	85.2	3.9	60.9
1	US H11	Susc.check	6200	22.97	13.48	162	7.0	84.9	4.1	54.5

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TEST 4194. CBGA/BSDF CODED RHIZOMANIA VARIETY TRIAL, SPENCE BLOCK 2S (MODERATE), SALINAS, CA., 1994

(cont.)

Variety Code	Variety Name[1]	Company	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Powdery Mildew[2] %	RJAP %	RZM Resistance[3] DI	RZM Resistance[3] %Resist.
USDA Entries and checks										
62	Rizor	RZ3/1022 SES 2915aa x C603-1	9211	28.22	16.32	158	6.6	81.8	2.8	92.3
64	N303H15		8439	30.98	13.58	158	6.5	82.4	3.4	75.2
63	R338H52	C790-15H39 x R38(C)	8397	29.02	14.46	163	5.1	83.4	3.2	75.9
61	6770	Susc.check	7224	23.42	15.38	159	4.9	85.1	4.6	41.3
60	US H11	Susc.check	5926	21.84	13.54	168	7.3	84.5	4.2	50.4
Mean			8204.0	27.46	14.91	153.4	5.1	83.7	3.2	81.5
LSD (.05)			859.7	2.71	0.52	14.8	1.2	1.6	0.5	16.1
C.V. (%)			10.7	10.03	3.55	9.8	23.0	2.0	8.0	9.9
F value			11.4**	7.42**	13.49**	4.2**	11.5**	2.4**	6.1**	6.2**

[1] USDA entries and checks: US H11 = highly susceptible check. 6770 = highly susceptible high %S check with adaptation to northern USA (and Salinas, see tests 894-1094). Rizor = resistant check from SES (Europe). R338H52 = USDA experimental hybrid with rhizomania resistance from many sources in C37 background. N303H15 = popn-915Rzaa x C603 = USDA experimental hybrid with dual resistance to rhizomania and cyst nematode.

[2] Powdery mildew scored 09/26/94 and 10/04/94 on a scale of 0 to 9 where 9 = 90-100% of leaf area covered with mildew. Until late in season, PM was controlled with Bayleton and probably had little influence on yield.

[3] Rhizomania scores for replications 7 & 8 where 1 = highly resistant; 3 = mod. resistant; 5 = susceptible; 7 = highly susceptible; and 9 = dead due to rhizomania. DI = disease index = average score for entry. % resistant = ratings 1 + 3 divided by total. r = -0.57 for sugar yield vs. DI and r = 0.67 for sugar yield vs. % resistant.

Notes: Field in nonrhizomania tests in 1991. In August 1993, rhizomania infested soil was broadcast over area and disced in, area was then bedded up, planted without subsequent thinning to susceptible sugarbeet, and frequently irrigated for two months. About Nov. 1, 1993, sugarbeets were disced under. In the spring of 1994, area was prepared for sugarbeet tests. In October 1993, plant samples were positive (ELISA) for BNYVV. In February 1994, soil samples proved to be uniformly positive for BNYVV. May 1994 planted rhizomania trials established and grew without problems. Field uniformity was very good and sugarbeet crop looked nearly normal for color and vigor. At harvest, rhizomania symptoms were mild. Cyst nematode and root aphid infestations were moderate. No root rot occurred.

TEST 4194. CBGA/BSDF CODED RHIZOMANIA VARIETY TRIAL, SPENCE BLOCK 2S (MODERATE), SALINAS, CA., 1994

(cont.)

Variety Variety Code Name[1]	Company	Acre Yield		Sucrose	Beets/ 100'	Powdery Mildew[2]	RJAP	RZM Resistance[3]	
		Sugar Lbs	Beets Tons	%	No.	%	%	DI %	%Resist.

Notes (cont.)

This test was designed as a 64 entry x 8 replications test. Entries 1 thru 53 were for CBGA coded rhizomania test. Entries 60 thru 64 were entries and checks added by USDA. Entries 54 thru 59 were from BSDF (Betaseed). Tests 3294 and 4194 involve the same sets of entries. Test 3294 was planted under known severe rhizomania conditions. Test 4194 was planted under unknown rhizomania conditions (first time under rhizomania tests after being infested in 1993). Rhizomania in test 4194 was moderate and fairly uniform. Plant growth was uniform and good. For tests 4294, 4194 , 3294 & 3394 gross sugar yield was used as the primary criteria to evaluate differences in resistance to rhizomania; in addition, in tests 4194 and 4294 two replications were hand harvested and scored for rhizomania symptoms. Based upon the known susceptible checks, only about half of the plants expressed fully susceptible symptoms. Thus, escapes were common. In general, if a plant was rated as susceptible, it was susceptible to rhizomania (BNYVV). If a plant was rated as resistant, it may have been resistant or an escape. (Escapes, as far as symptoms on tap roots were concerned, but most likely lateral and feeder roots were infected.) It is still my judgement that gross sugar yield is the best measure of resistance to rhizomania when the relative yield of the entries under nonrhizomania conditions also is known in the area of their adaptation.

For Tests 4194 (moderate rhizomania) and 3294 (severe rhizomania), there was a rank correlation for sugar yield of r = 0.87. This suggested that these 64 varieties separated out into essentially the same order for sugar yield when tested under different degrees of disease severity. The correlation between disease scores (% resistant roots) and sugar yield further suggests that the ranking is primarily due to the level or frequency of resistant plants within a set of entries. It is also of interest to note that the relative ranking for sugar yield for varieties within these rhizomania tests at Salinas is very similar to their ranking in the CBGA rhizomania test run by Holly Sugar in 1994 in the Glenn, CA area. But the ranking is not well associated with the CBGA rhizomania trial run by Holly Sugar in 1994 in the Tracy area in which there did not appear to be rhizomania. Thus, these trials at Salinas, based upon sugar yield, seem to primarily measure resistance to rhizomania and to a lesser extent yield potential and relative adaptation.

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TEST 3394. WS/HG JOINT TEST FOR EVALUATION OF RHIZOMANIA RESISTANCE (SEVERE), 1994

16 entries x 4 replications, RCB
1-row plots, 20 ft. long

Planted: April 20, 1994
Harvested: October 20, 1994

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %
WS/HG entries						
Maribo 9372	American Crystal	7798	22.77	17.15	180	83.2
Beta 2J0152	Betaseed	7796	22.79	17.07	179	84.5
Beta 2J0179	Betaseed	7655	21.70	17.63	136	82.9
SX0212	Seedex	7425	21.99	16.90	175	84.5
Rhizosen	Holly	7089	22.37	15.90	215	82.9
HM 1626	Hilleshog-Monohy	6678	20.06	16.70	210	80.2
93HX228	Holly	6099	20.58	14.80	218	84.2
Rhizosen CT	Holly	5838	18.59	15.68	201	84.7
Monohikari	Seedex (check)	5610	18.69	15.00	208	85.4
Rhizoguard	Holly	5282	17.28	15.27	194	82.8
USDA entries and checks						
R222R4	RZM R122R3	9125	30.24	15.15	203	81.4
N303H15	2915aa x C603-1	7898	26.25	15.20	215	84.7
Rizor	RZ 3/1022 (1993)	7858	22.68	17.30	205	81.9
R376H52	790-15H39 x R276,Y	6850	21.49	16.08	215	85.4
R338H52	790-15H39 x R38(C)	6410	21.32	15.10	206	83.2
US H11	113401	4444	15.86	13.98	188	83.1
Mean		6865.8	21.54	15.93	196.6	83.4
LSD (.05)		1266.2	4.10	0.98	37.6	3.1
C.V. (%)		13.0	13.37	4.31	13.4	2.6
F value		7.3**	5.59**	9.83**	2.6**	1.9*

[1] USDA entries and checks: US H11 = highly susceptible hybrid. Rizor = resistant check from SES(Europe). N303H15 = popn-915Rzaa x C603 = experimental hybrid with dual resistance to rhizomania and cyst nematode. R222R4 = 4th cycle selection from sugarbeet x B.maritima. R338H52 = USDA experimental hybrid with rhizomania resistance from many sources in C37 background. R376H52 = USDA experimental hybrid with pollinator similar to C31/6Rz.

Note: Rhizomania was very severe. This was the third sugarbeet crop in rhizomania tests in five years. In addition, cyst nematode was moderate. Root aphids were mild. Stands were good and the usual problem with seedling loss (Aphanomyces) was not experienced. Nitrogen was applied as if a normal crop, but canopy suggested nitrogen deficiency, probably due to an impaired root system not being able to forage for nitrogen, other nutrients, and water efficiently. Even under moist and cool conditions, plants wilted most afternoons. There was no loss of plants due to root rots.

TEST 4294. WS/HG JOINT TEST FOR EVALUATION OF RHIZOMANIA RESISTANCE (MODERATE), SALINAS, CA., 1994

Planted: May 10, 1994
Harvested: October 24-25, 1994

16 entries x 8 replications, RCB
1-row plots, 20 ft. long

| Variety | Description[1] | Acre Yield | | Sucrose | Beets/100' | Powdery Mildew[2] | RJAP | RZM Resistance[3] | |
		Sugar Lbs	Beets Tons	%	No.	%	%	DI	%Resist.
WS/HG entries									
Beta 2J0179	Betaseed	9849	28.70	17.17	125	6.1	83.3	2.65	100.0
Beta 2J0152	Betaseed	9075	28.28	16.02	141	4.6	83.5	2.79	88.3
Maribo 9372	American Crystal	8234	25.74	15.99	166	5.4	82.4	3.33	76.1
Rhizosen	Holly	8161	26.93	15.13	153	7.4	84.4	3.07	77.1
SX0212	Seedex	7923	25.33	15.59	153	7.5	84.9	4.07	46.6
HM 1626	Hilleshog-Monohy	7165	21.89	16.34	178	6.5	82.5	3.44	69.9
Rhizosen CT	Holly	6859	23.19	14.81	179	6.6	85.0	2.25	90.6
93HX228	Holly	6419	22.79	14.08	159	8.1	86.2	3.85	50.8
Rhizoguard	Holly	6413	22.65	14.13	155	7.3	84.3	3.22	64.6
Monohikari	Seedex (check)	6390	19.98	15.94	172	7.3	86.0	3.58	54.3
USDA checks and entries									
Rizor	RZ 3/1022 (1993)	9054	27.26	16.59	159	8.3	82.1	2.51	93.5
R376H52	790-15H39 x R276,Y	8732	30.19	14.46	165	5.8	83.9	1.91	92.4
R222R4	RZM R122R3	8199	28.97	14.14	169	7.8	80.5	1.69	100.0
R338H52	790-15H39 x R38(C)	7585	25.41	14.94	157	8.0	84.1	1.96	88.8
N303H15	2915aa x C603-1	7555	27.41	13.78	158	8.8	83.2	2.69	72.6
US H11	113401	5528	19.64	14.04	171	9.0	85.0	3.51	54.8
Mean		7696.3	25.27	15.20	159.9	7.1	83.8	2.91	76.3
LSD (.05)		505.6	1.52	0.43	14.0	1.3	1.3	1.33	24.2
C.V. (%)		6.6	6.06	2.88	8.9	17.9	1.5	21.45	14.9
F value		42.9**	36.07**	46.76**	7.5**	7.4**	11.1**	2.64*	5.0**

[1] USDA entries and checks: US H11 = highly susceptible hybrid. Rizor = resistant check from SES (Europe). N303H15 = popn-915Rzaa x C603 = experimental hybrid with dual resistance to rhizomania and cyst nematode. R222R4 = 4th cycle selection from sugarbeet x B.maritima. R338H52 = USDA experimental hybrid with rhizomania resistance from many sources in C37 background. R376H52 = USDA experimental hybrid with pollinator similar to C31/6Rz.

[2] Powdery mildew scored 09/26/94 and 10/04/94 on a scale of 0 to 9 where 9 = 90-100% of leaf area covered with mildew. Until late in season, PM was controlled with Bayleton and probably had little influence on yield.

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TEST 4294. WS/HG JOINT TEST FOR EVALUATION OF RHIZOMANIA RESISTANCE (MODERATE), SALINAS, CA., 1994

(cont.)

Variety	Description[1]	Acre Yield		Sucrose %	Beets/ 100' No.	Powdery Mildew[2] %	RJAP %	RZM Resistance[3]	
		Sugar Lbs	Beets Tons					DI %	%Resist. %

[3] Rhizomania scores for replications 7 & 8 where 1 = highly resistant; 3 = mod. resistant; 5 = susceptible; 7 = highly susceptible; and 9 = dead due to rhizomania. DI = disease index = average score for entry. % resistant = ratings 1 + 3 divided by total. $r = -0.45$ for sugar yield vs. DI and $r = 0.71$ for sugar yield vs. % resistant.

Notes: Field in nonrhizomania tests in 1991. In August 1993, rhizomania infested soil was broadcast over area and disced in. Area was then bedded up, planted without subsequent thinning to susceptible sugarbeet and frequently irrigated for two months. About Nov. 1, 1993, sugarbeets were disced under. In the spring of 1994, area was prepared for sugarbeet tests. In October 1993, plant samples were positive (ELISA) for BNYVV. In February 1994, soil samples proved to be uniformly positive for BNYVV. May 1994 planted rhizomania trials established and grew without problems. Field uniformity was very good and sugarbeet crop looked nearly normal for color and vigor. At harvest rhizomania symptoms were moderate. Cyst nematode and root aphid infestations were mild. No root rot occurred.

For tests 4294, 4194, 3294 & 3394 gross sugar yield was used as the primary criteria to evaluate differences in resistance to rhizomania; in addition, in tests 4194 and 4294 two replications were hand harvested and scored for rhizomania symptoms. Based upon the known susceptible checks, only about half of the plants expressed fully susceptible symptoms. Thus, escapes were common. In general, if a plant was rated as susceptible, it was susceptible to rhizomania (BNYVV). If a plant was rated as resistant, it may have been resistant or an escape. (Escapes, as far as symptoms on tap roots were concerned, but most likely lateral and feeder roots were infected.) It is still my judgement that gross sugar yield is the best measure of resistance to rhizomania when the relative yield of the entries under nonrhizomania conditions also is known in the area of their adaptation.

For tests 4294 (moderate rhizomania) and 3394 (severe rhizomania), there was a rank correlation for sugar yield of $r = 0.79$. This suggests that varieties separate out into essentially the same ranking for sugar yield which tested under varying degrees of disease severity. The correlation between disease scores (% resistant) and sugar yield further suggests that the ranking is primarily due to the level of resistance or frequency of resistant plants within a set of entries. In tests run by Steve Godby in Western Sugar's A-area (Alliance, Scottsbluff, Bayard, NE; and Berthoud, CO) without known rhizomania, the mean sugar yield for the common entries with tests 4294 and 3394 was 2J0179 (8106 recoverable lbs/a), 2J0152 (7719), Monohikari (7663), SX0212 (7490), M9372 (7334), 93HX228 (6999), Rhizosen (6951), and HM1626 (6728). The A-area tests had an LSD of 365 and a CV of 8.7.

TEST 694. BOLTING/RHIZOMANIA/ERWINIA/PM EVALUATION AND SELECTION OF MONOGERM PROGENIES, SALINAS, CA., 1993-94

Planted: November 15, 1993
Harvested: September , 1994

64 entries x 1-2 replications
1-row plots, 18 ft. long

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	(07/05/94) Bolters %	(08/23/94) Bolters %	(09/09/94) Bolters %	Root Rot %
3867- 1	2867mmA ⊗	9200	31.51	14.60	122	0.0	9.1	9.1	0.0
- 2		8269	28.91	14.30	117	4.8	9.5	9.5	0.0
- 3		9212	27.10	17.00	50	0.0	0.0	0.0	0.0
- 4		6091	19.46	15.65	117	4.8	4.8	4.8	0.0
- 5		8722	25.73	16.95	139	0.0	4.0	4.0	0.0
- 6		8673	27.80	15.60	128	13.0	17.4	26.1	0.0
- 7		9301	28.36	16.40	111	0.0	5.0	5.0	0.0
- 8		8048	26.13	15.40	122	0.0	4.5	4.5	0.0
- 9		5243	16.38	16.00	122	4.5	4.5	4.5	4.5
-10		9641	31.51	15.30	128	4.3	4.3	8.7	0.0
-11		6588	21.53	15.30	106	0.0	0.0	5.3	0.0
-12		7631	25.02	15.25	128	0.0	4.3	4.3	0.0
-13		6336	20.57	15.40	111	5.0	5.0	5.0	0.0
-14		8308	28.36	14.65	106	5.3	26.3	31.6	0.0
3890- 1	2890mmA ⊗	9718	29.54	16.45	122	0.0	0.0	0.0	0.0
- 2		6574	21.00	15.65	122	0.0	4.5	4.5	0.0
- 3		6631	21.53	15.40	128	0.0	0.0	0.0	0.0
- 4		7488	23.04	16.25	133	0.0	0.0	0.0	0.0
- 5		9830	31.51	15.60	133	0.0	0.0	0.0	0.0
- 6		6448	21.00	15.35	139	0.0	0.0	0.0	0.0

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TEST 694. BOLTING/RHIZOMANIA/ERWINIA/PM EVALUATION AND SELECTION OF MONOGERM PROGENIES,
SALINAS, CA., 1993-94

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	(07/05/94) Bolters %	(08/23/94) Bolters %	(09/09/94) Bolters %	Root Rot %
3890- 7	2890mmA ⊗	7968	27.76	14.35	111	0.0	0.0	0.0	0.0
- 8		6196	21.00	14.75	133	0.0	0.0	0.0	0.0
- 9		6227	22.24	14.00	117	0.0	0.0	0.0	4.8
-10		9147	28.95	15.80	106	0.0	0.0	0.0	0.0
-11		8395	27.80	15.10	106	0.0	0.0	5.3	0.0
-12		11505	36.76	15.65	122	0.0	0.0	0.0	0.0
-13		5293	18.38	14.40	128	0.0	0.0	0.0	0.0
-14		6668	20.09	16.60	106	0.0	5.3	5.3	0.0
-15		6590	26.25	12.55	122	4.5	9.1	9.1	0.0
-16		9094	27.73	16.40	100	0.0	0.0	0.0	0.0
-17		11785	41.35	14.25	111	0.0	0.0	0.0	0.0
-18		9668	29.93	16.15	117	0.0	0.0	0.0	0.0
-19		12799	39.38	16.25	100	0.0	0.0	0.0	0.0
-20		9187	28.36	16.20	122	0.0	0.0	0.0	0.0
-21		8062	27.80	14.50	78	21.4	50.0	64.3	0.0
-22		11329	35.18	16.10	128	0.0	0.0	0.0	8.7
-23		10624	37.81	14.05	133	0.0	0.0	0.0	0.0
-24		6007	20.57	14.60	106	0.0	0.0	0.0	0.0
-27		11889	40.03	14.85	128	0.0	0.0	0.0	0.0
-28		10308	34.13	15.10	133	0.0	16.7	20.8	0.0
-29		10379	35.18	14.75	117	0.0	0.0	0.0	0.0
-30		9481	29.54	16.05	100	0.0	0.0	0.0	0.0
-31		11141	35.71	15.60	106	0.0	0.0	0.0	0.0
-32		7748	25.40	15.25	106	5.3	10.5	10.5	0.0

TEST 694. BOLTING/RHIZOMANIA/ERWINIA/PM EVALUATION AND SELECTION OF MONOGERM PROGENIES, SALINAS, CA., 1993-94

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	(07/05/94) Bolters %	(08/23/94) Bolters %	(09/09/94) Bolters %	Root Rot %
3890-33	2890mmA ⊗	8743	26.25	16.65	122	0.0	0.0	0.0	0.0
-34		10523	31.51	16.70	122	0.0	0.0	0.0	0.0
-35		9494	33.08	14.35	122	0.0	0.0	0.0	0.0
-36		10686	34.47	15.50	122	0.0	4.5	9.1	0.0
-37		9420	31.51	14.95	133	0.0	0.0	0.0	0.0
-38		8266	27.83	14.85	139	0.0	4.0	4.0	0.0
-39		10623	36.76	14.45	122	0.0	0.0	0.0	0.0
-40		9326	31.51	14.80	128	0.0	0.0	0.0	0.0
-41		11095	36.14	15.35	106	0.0	0.0	0.0	0.0
-42		8090	27.80	14.55	100	0.0	0.0	0.0	0.0
-43		10958	38.86	14.10	128	0.0	0.0	0.0	0.0
-44		9137	31.51	14.50	122	0.0	0.0	0.0	0.0
-45		8601	31.51	13.65	122	0.0	0.0	0.0	0.0
-46		9079	34.13	13.30	122	0.0	0.0	0.0	0.0
-47		8260	34.85	11.85	106	0.0	0.0	0.0	0.0
-48		9452	31.51	15.00	111	0.0	0.0	0.0	0.0
-49		12488	41.35	15.10	128	0.0	8.7	8.7	0.0
-50		14130	47.26	14.95	106	5.3	5.3	5.3	0.0
-51		9520	36.76	12.95	128	0.0	0.0	0.0	0.0
-52		10513	36.76	14.30	106	0.0	0.0	0.0	0.0

TEST 394. BOLTING/RHIZOMANIA/ERWINIA/PM EVALUATION AND SELECTION OF MULTIGERM S^f PROGENIES, SALINAS, CA., 1993-94

Planted: November 15, 1993
Harvested: September   , 1994

108 entries x 1 replication
1-row plots, 18 ft. long

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	(07/05/94) Bolters %	(08/23/94) Bolters %	(09/09/94) Bolters %	Root Rot %
3911-4- 1	2911-4 ⊗	14115	50.41	14.00	156	0.0	0.0	0.0	0.0
- 2		9791	38.40	12.75	139	0.0	0.0	0.0	0.0
- 3		8693	28.88	15.05	133	0.0	0.0	0.0	0.0
- 4		10135	34.47	14.70	150	0.0	0.0	0.0	7.4
- 5		0	0.0	0.0	0	0.0	0.0	0.0	0.0
- 6		8818	28.91	15.25	122	0.0	0.0	0.0	0.0
- 7		12093	36.76	16.45	145	0.0	0.0	0.0	0.0
- 8		8386	30.72	13.65	111	0.0	0.0	0.0	0.0
- 9		8534	27.01	15.80	11	0.0	0.0	0.0	0.0
-10		9857	31.90	15.45	95	0.0	0.0	0.0	0.0
-11		5671	18.18	15.60	100	0.0	0.0	0.0	0.0
-12		9956	31.51	15.80	39	0.0	0.0	0.0	0.0
3911-12-1	2911-12 ⊗	8847	27.31	16.20	122	100.0	100.0	100.0	0.0
-2		0	0.0	0.0	0	0.0	0.0	0.0	0.0
-3		4861	18.27	13.30	95	0.0	0.0	0.0	0.0
-4		3403	11.81	14.40	39	0.0	0.0	0.0	0.0
3911-14-1	2911-14 ⊗	3702	13.13	14.10	145	0.0	0.0	0.0	3.8
-2		4694	15.75	14.90	145	0.0	0.0	0.0	0.0
-3		3781	13.13	14.40	150	0.0	0.0	0.0	0.0
-4		0	0.0	0.0	0	0.0	0.0	0.0	0.0
-5		3529	12.60	14.00	156	0.0	0.0	0.0	0.0
-6		2301	8.10	14.20	100	0.0	0.0	0.0	0.0
3911-50-1	2911-50 ⊗	4423	16.38	13.50	156	3.6	3.6	3.6	0.0
-2		0	0.0	0.0	0	0.0	0.0	0.0	0.0
-3		4757	15.75	15.10	122	50.0	40.9	36.4	0.0
-4		1922	7.88	12.20	111	0.0	5.0	5.0	0.0

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TEST 394. BOLTING/RHIZOMANIA/ERWINIA/PM EVALUATION AND SELECTION OF MULTIGERM S[f] PROGENIES, SALINAS, CA., 1993-94

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	(07/05/94) Bolters %	(08/23/94) Bolters %	(09/09/94) Bolters %	Root Rot %
3911-50-5	⊗	9204	30.58	15.05	106	0.0	5.3	15.8	0.0
-6		0	0.00	15.80	6	0.0	100.0	100.0	0.0
-7		7612	25.20	15.10	95	5.9	11.8	5.9	5.9
-8		6115	21.08	14.50	89	12.5	25.0	31.3	0.0
3911-24-1	⊗	5744	20.09	14.30	133	0.0	8.3	0.0	0.0
-2		6062	19.43	15.60	156	3.6	0.0	0.0	0.0
-3		5171	16.68	15.50	139	0.0	0.0	0.0	0.0
-4		8218	26.25	15.65	139	16.0	16.0	20.0	12.0
-5		4130	14.54	14.20	139	4.0	0.0	0.0	0.0
-6		4744	15.01	15.80	145	0.0	7.7	7.7	0.0
-7		5665	20.68	13.70	139	16.0	16.0	20.0	0.0
-8		6343	21.00	15.10	183	3.0	12.1	12.1	0.0
-9		3052	10.31	14.80	133	0.0	8.3	4.2	0.0
-10		15548	47.26	16.45	111	25.0	30.0	0.0	0.0
-11		7543	24.81	15.20	106	0.0	0.0	0.0	0.0
-12		4809	15.12	15.90	106	0.0	0.0	0.0	0.0
-13		4666	16.20	14.40	72	0.0	0.0	0.0	0.0
-14		1850	6.75	13.70	128	30.4	21.7	13.0	8.7
-15		4852	15.75	15.40	95	0.0	0.0	5.9	0.0
3913-5- 1	⊗	7527	24.68	15.25	150	0.0	0.0	0.0	7.4
- 2		9452	31.51	15.00	122	0.0	0.0	0.0	0.0
- 3		3261	11.81	13.80	100	0.0	0.0	0.0	16.7
- 4		9913	32.72	15.15	106	5.3	10.5	10.5	0.0
- 5		9007	33.36	13.50	117	0.0	0.0	0.0	0.0
- 6		7696	33.61	11.45	83	0.0	0.0	6.7	0.0
- 7		7584	27.68	13.70	78	0.0	0.0	0.0	0.0
- 8		6087	18.90	16.10	100	0.0	0.0	0.0	5.6
- 9		9365	33.44	14.00	95	0.0	0.0	0.0	0.0
-10		12004	47.26	12.70	28	0.0	40.0	40.0	0.0

TEST 394. BOLTING/RHIZOMANIA/ERWINIA/PM EVALUATION AND SELECTION OF MULTIGERM S' PROGENIES, SALINAS, CA., 1993-94

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	(07/05/94) Bolters %	(08/23/94) Bolters %	(09/09/94) Bolters %	Root Rot %
3913-9- 1	⊗	4713	17.85	13.20	150	0.0	0.0	0.0	0.0
- 2		7903	26.25	15.05	139	0.0	0.0	0.0	0.0
3013-18- 1		9721	36.14	13.45	106	5.3	10.5	10.5	0.0
- 2		7299	26.25	13.90	133	8.3	12.5	12.5	0.0
- 3		11016	42.53	12.95	111	10.0	20.0	20.0	0.0
- 4		9598	33.92	14.15	111	0.0	0.0	0.0	5.0
- 5		6812	24.15	14.10	89	0.0	0.0	0.0	0.0
- 6		7599	28.36	13.40	133	8.3	16.7	25.0	0.0
- 7		8146	25.78	15.80	95	5.9	5.9	5.9	23.5
- 8		8654	29.54	14.65	100	0.0	0.0	0.0	0.0
- 9		4503	16.80	13.40	111	80.0	50.0	75.0	5.0
-10		11730	41.75	14.05	78	0.0	0.0	0.0	0.0
3913-22- 1	⊗	9200	31.51	14.60	111	0.0	0.0	0.0	0.0
- 2		4963	17.85	13.90	133	0.0	0.0	4.2	0.0
- 3		9816	35.18	13.95	139	0.0	4.0	4.0	0.0
- 4		10103	34.13	14.80	133	0.0	12.5	12.5	0.0
- 5		8707	29.62	14.70	150	0.0	0.0	0.0	11.1
3913-22- 6	⊗	5104	17.72	14.40	139	0.0	0.0	0.0	24.0
- 7		9011	34.13	13.20	145	0.0	0.0	3.8	0.0
- 8		9597	33.67	14.25	111	5.0	10.0	10.0	0.0
- 9		10660	36.76	14.50	139	0.0	0.0	0.0	0.0
-10		10218	36.76	13.90	128	30.4	34.8	34.8	0.0
3913-25- 1	⊗	7156	25.02	14.30	150	0.0	0.0	0.0	22.2
- 2		0	0.0	0.0	0	0.0	0.0	0.0	0.0

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TEST 394. BOLTING/RHIZOMANIA/ERWINIA/PM EVALUATION AND SELECTION OF MULTIGERM S′ PROGENIES, SALINAS, CA., 1993-94

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	(07/05/94) Bolters %	(08/23/94) Bolters %	(09/09/94) Bolters %	Root Rot %
3915-4-1	2915-4 ⊗	6330	22.45	14.10	145	0.0	0.0	0.0	26.9
-2		7824	26.25	14.90	106	0.0	0.0	0.0	0.0
-3		7745	26.25	14.75	128	8.7	30.4	30.4	0.0
-4		10035	34.13	14.70	133	0.0	0.0	0.0	0.0
-5		8201	27.80	14.75	111	0.0	0.0	0.0	0.0
-6		7220	26.25	13.75	106	0.0	5.3	10.5	0.0
3915-7-1	2915-7 ⊗	9079	34.13	13.30	145	15.4	23.1	23.1	0.0
-2		4915	17.19	14.30	150	0.0	0.0	0.0	0.0
-3		4323	15.01	14.40	111	5.0	5.0	5.0	0.0
-4		0	0.0	0.0	0	0.0	0.0	0.0	0.0
-5		6246	22.80	13.70	139	0.0	0.0	0.0	0.0

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72 entries x 3 replications   Planted: November 15, 1993
1-row plots, 18 ft. long   Not harvested for yield

Variety	Description	Stand Count No.	Beets/ 100' No.	% Bolting 07/05	% Bolting 08/23
SP 7622-O	L80466 (8/87)	21.7	120	59.6	65.3
268	Inc. 768 (US 75)	23.7	132	0.0	2.8
U86-37	C37, 86443	25.3	141	2.7	5.3
R338-1	RZM R279R2 x R38(C)	23.7	132	9.9	18.0
R338-4	R221 x R38(C)	24.0	133	12.6	16.9
R379	RZM R279R2,R279(Iso),R279Y	24.7	137	14.7	16.1
R338-13	RZM 2243-#(C) x R38(C)	23.7	132	9.8	24.0
R338-15	RZM 2247-#(C) x R38(C)	25.0	139	17.0	23.9
R338-5	RZM 2201-#(C) x R38(C)	24.7	137	2.6	5.4
U86-46/2	C46/2, 86342	24.3	135	1.4	1.4
R378(Iso)	RZM R278(Iso)	26.3	146	1.2	3.7
R378(Sp)	RZM R278, R278Y	23.7	132	9.8	11.3
F86-31/6	C31/6, 86263	19.3	107	0.0	2.2
R276(Iso)	RZM R076	25.0	139	12.2	24.5
R276Y(Iso)	RZM-BYV-ER R076	23.0	128	7.3	14.3
R376(Iso)	RZM R276(Iso)	25.3	141	10.1	18.1
R376(Sp)	RZM R276 #'s	22.7	126	13.1	17.6
R376Y(Iso)	RZM R276Y	22.7	126	3.0	7.4
Y231-43	Inc. Y131-43	24.3	135	1.5	4.1
R276-43(Iso)	RZM R176-43	25.7	143	2.5	14.0
R376-43(Iso)	RZM R276-43	26.3	146	4.0	11.4
R376-43-14	Inc. R176-43-14	26.0	145	2.5	5.1
R376-43-15	Inc. R176-43-15	25.0	139	0.0	0.0
R376-43-#(C)	Inc. R176-43-#(C) (C76-43)	27.7	154	0.0	1.2
Y231-89	Inc. Y131-89	25.0	139	0.0	0.0
R276-89(Iso)	RZM R176-89	28.0	156	5.7	16.1
R376-89(Iso)	RZM R276-89	26.7	148	3.6	17.6
R376-89-5	Inc. R176-89-5	26.3	146	1.3	3.8
R376-89-18	Inc. R176-89-18	26.0	145	1.2	6.2
R376-89-#(C)	Inc. R176-89-#(C) (C76-89)	28.0	156	2.5	7.2
R384	Inc. R176-43;-89-#	24.3	135	3.9	5.7
R282(Sp)	Inc. R176-43;-89	25.3	141	13.2	27.6
R239C8	RZM R139C7 (C39R)	24.0	133	16.9	33.6
Y339	YR-ER-PMR Y139 (C39)	23.3	130	0.0	5.7
R247C8	RZM R147C7 (C47R)	25.0	139	6.7	14.3
Y347	YR-ER-PMR Y147 (C47)	24.0	133	2.9	8.5
U86-37	C37, 86443	24.3	135	0.0	2.8
SP 7622-O	L80466 (8/87)	25.7	143	40.2	66.3
E840	Inc. E440	27.0	150	1.3	6.3
R380(Iso)	RZM R280(Iso)	22.7	126	1.4	1.4
R380(Sp)	RZM R280,R280Y	23.7	132	3.0	7.3
N354(Iso)	NR-RZM N254-#-#(C)	24.7	137	1.6	4.1
R309	RZM R209-#(C)	22.0	122	3.2	11.0
R310	RZM R210-#(C)	24.3	135	13.4	31.9
R322R4(%)	RZM R122R3(%S)	27.3	152	52.3	51.2
R322R4	RZM R122R3(GSY)	24.3	135	37.6	53.5
R322Y3(%)	YR-ER-PMR R122Y2 (%S)	24.7	137	5.2	24.0
R322Y3	YR-ER-PMR R122Y2 (GSY)	23.7	132	34.4	41.4
R328	RZM 2202-#(C), (PI07)	25.3	141	1.3	7.9
R329	RZM 2206-#(C), (PI07)	23.7	132	1.5	1.5

TEST 794.   BOLTING EVALUATION OF BREEDING LINES, SALINAS, CA., 1993-94

(cont.)

Variety	Description	Stand Count	Beets/ 100'	% Bolting	
		No.	No.	07/05	08/23
R332	RZM 2201-#(C), (R04)	24.0	133	14.9	29.2
R333	RZM 2205-#(C), (R04)	24.3	135	49.4	57.6
R334	RZM 2245-#(C), (R05)	25.7	143	2.5	15.2
R335	RZM 2242-#(C), (Rima)	26.0	145	3.8	11.6
R336	RZM 2243-#(C), (R22)	28.3	158	7.1	12.8
R337	RZM 2247-#(C), (W3)	26.3	146	12.8	10.2
3915(Sp)	RZM 2911,...,2915aa x A	23.0	128	0.0	2.8
3918-#(C)(Iso)	Inc. 1913-#,1915-#(S₁)(A,aa)	25.0	139	1.4	0.0
3918(Sp) (C918)	1913-#,1915-#(S₁)aa x A	24.7	137	0.0	5.2
3913-3	Inc. 1913-3(S₁)	26.0	145	1.2	3.9
3913-51	Inc. 1913-51(S₁)	25.7	143	2.3	2.3
3913-70	Inc. 1913-70(S₁)	28.0	156	0.0	0.0
3913-71	Inc. 1913-71(S₁)	27.3	152	2.5	2.5
3859(Iso)(C859)	RZM 2859m(Sp)(A,aa)	25.0	139	4.1	9.6
2865(Iso)	RZM 1865-#(C)(A,aa)	25.7	143	0.0	8.2
3865	Inc. 1865-#'s (A,aa),(NB sel.)	28.0	156	3.6	13.2
3864-1H50	C92-790-15CMS x RZM, O-T 2864-1-#	21.7	120	4.6	7.6
3864-5	0864-5 x	26.0	145	1.2	6.4
3864-8	0864-8 x	24.7	137	55.4	58.3
3864-14	0864-14 x	25.0	139	14.8	25.2
3864-25	0864-25 x	25.7	143	0.0	1.3
3864-34	0864-34 x	22.3	124	0.0	8.9
Mean		24.9	138.3	8.8	14.8
LSD (.05)		3.3	18.6	9.6	11.9
C.V. (%)		8.3	8.3	67.6	49.8
F value		2.0**	2.0**	16.1**	14.5**

$I_{\text{subscripts}}$ are S_1

TEST 494.   BOLTING/RHIZOMANIA/ERWINIA/POWDERY MILDEW EVALUATION
AND SELECTION OF MONOGERM POPULATIONS, SALINAS, CA., 1993-94

5 entries x 1 replication   Planted: November 15, 1993
1-row plots, 1 row long   Not harvested for yield

Variety	Description	Stand Count	% Bolting	
		No.	07/05	08/23
mm,S^f,A:aa,Rz Populations				
3859m(Sp)	2859mmaa x A	1034.0	2.1	6.0
3867m(Sp)	2867mmaa x A	1009.0	3.6	9.4
3890 (C890)	0790mmaa x 2890	920.0	0.0	0.3
3893m	Rz(C)mmaa x mm,O-T(C)	934.0	2.7	6.1
3894m	RzMR(C)mmaa x A	934.0	4.8	15.8

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TEST 294-1. BOLTING/RHIZOMANIA/ERWINIA/POWDERY MILDEW EVALUATION AND SELECTION OF MULTIGERM LINES, SALINAS, CA., 1993-94

23 entries x 1 replication   Planted: November 15, 1993
1-row plots, 1/6 to 2 rows long   Not harvested for yield

Variety	Description	Stand Count No.	% Bolting 07/05	% Bolting 08/23
MM,O.P.,Lines				
R370	RZM R270Y	943	13.4	13.4
R376(Iso)	RZM R276(Iso)	474	20.5	32.7
R376Y(Iso)	RZM R276Y(Iso)	438	11.4	20.1
R381-43(Iso)	RZM R281-43	450	14.7	31.1
R381-89(Iso)	RZM R281-89	418	11.0	23.9
R384(Sp)	Inc. R176-43-#;-89-#	828	4.8	10.6
R376-43-14	Inc. R176-14-14	166	1.8	9.0
R376-43-15	Inc. R176-43-15	116	0.0	0.0
R376-43-#(C)	Inc. R176-43-#(C) (C76-43)	139	0.0	0.7
R376-89-5	Inc. R176-89-5	138	0.0	2.9
R376-89-18	Inc. R176-89-18	131	3.8	7.6
R376-89-#(C)	Inc. R176-89-#(C) (C76-89)	144	2.8	8.3
R378(Iso)	RZM R278(Iso)	484	5.6	13.4
R378Y(Iso)	RZM R278Y	524	3.2	12.0
R380(Iso)	RZM R280(Iso)	411	3.4	8.5
R380Y(Iso)	RZM R280Y	592	2.0	4.9
R383	Composite rr x R283R	1750	11.0	23.9
R139C7	RZM R039C6 (C39R)	903	6.0	15.7
R147C7	RZM R147C7 (C47R)	952	12.9	30.1
R379	RZM R279R2,R279(Iso),R279Y	228	22.4	30.7
R338-1	RZM R279R2 x R38(C)	216	4.6	16.2
R338-2	RZM R279(Iso) x R38(C)	226	12.8	23.5
R338-3	RZM R279Y x R38(C)	222	5.9	10.8

TEST 294-2.   BOLTING/RHIZOMANIA/ERWINIA/POWDERY MILDEW EVALUATION AND SELECTION OF MULTIGERM POPULATIONS, SALINAS, CA., 1993-94

7 entries x 1 replication
1-row plots, 1/2 to 2 rows long

Planted: November 15, 1993
Not harvested for yield

Variety	Description	Stand Count No.	% Bolting 07/05	08/23
MM,S^f,A:aa,Rz POPULATIONS				
3915(Sp)	2911Y,...,2915aa x A	1832.0	1.4	4.7
3918(Sp) (C918)	1913-S$_1$,1915-S$_1$aa x A	866.0	0.7	2.4
3916	RZM 2916(A,aa)	463.0	3.5	4.5
Z325	RZM Z120,...,Z124(A,aa)	481.0	2.5	5.8
Z330	RZM Z230(A,aa)	472.0	2.8	8.3
3917	RZM 2917-#(C), (Y39aa x A)	443.0	0.9	14.7
3911	YR-ER-PMR Popn-911,...(A,aa)	948.0	4.0	11.0

TEST 294-3.   BOLTING/RHIZOMANIA/ERWINIA,POWDERY MILDEW EVALUATION AND SELECTION OF MULTIGERM S^f LINES, SALINAS, CA., 1993-94

31 entries x 1 replication
1-row plots, 1/6 to 1 row long

Planted: November 15, 1993
Not harvested for yield

Variety	Description	Stand Count No.	% Bolting 07/05	08/23
MM,S^f,A:aa,Rz Lines				
3909-34	RZM 0909-34, (C909-34)	117.0	11.1	27.4
3909-37	RZM 0909-37, (C909-37)	127.0	3.9	13.4
3911-4	2911-4Maa x A, (C911-4)	121.0	0.0	0.8
3911-12	2911-12aa x A, (C911-12)	156.0	0.0	1.9
3911-14	2911-14Maa x A, (C911-14)	135.0	5.2	19.3
3911-50	2911-50aa x A, (C911-50)	141.0	0.0	0.7
3913-5	2913-5aa x A	154.0	0.0	0.6
3913-18	2913-18aa x A	166.0	1.8	6.6
3913-22	2913-22aa x A	166.0	0.6	2.4
3913-25	2913-25aa x A	140.0	0.7	2.1
3911-1	RZM 0911-1 (A,aa)	166.0	0.0	1.2
3911-4(B)	RZM 0911-4(B) (A,aa)	174.0	2.9	7.5
3911-24	RZM 2911-24 (A,aa)	153.0	1.3	4.6
3913-6	RZM 0913-6 (A,aa)	137.0	0.7	0.7
3913-9	RZM 2913-9 (A,aa)	141.0	0.0	0.7
3915-1	RZM 0915-1 (A,aa)	140.0	0.0	3.6
3915-4	RZM 2915-4 (A,aa)	148.0	5.4	14.2
3915-6	RZM 0915-6 (A,aa)	136.0	0.0	5.1
3915-7	RZM 2915-7 (A,aa)	147.0	0.0	0.0
3915-16	RZM 0915-16 (A,aa)	135.0	0.0	0.0
3915-22	RZM 0915-22 (A,aa)	145.0	0.0	0.0
3915-23	RZM 0915-23 (A,aa)	153.0	0.0	2.6
3915-24	RZM 0915-24 (A,aa)	152.0	3.3	7.2
3915-27	RZM 0915-27 (A,aa)	146.0	0.0	3.4
3915-34	RZM 0915-34 (A,aa)	164.0	0.0	1.2
3915-46	RZM 2915-46 (A,aa)	146.0	0.0	0.0
3913-3	Inc. 1913-3(S$_1$) (A,aa)	154.0	0.6	1.3
3913-51	Inc. 1913-51(S$_1$) (A,aa)	166.0	0.0	1.2
3913-70	Inc. 1913-70(S$_1$) (A,aa)	180.0	0.0	0.0
3913-71	Inc. 1913-71(S$_1$) (A,aa)	139.0	0.7	3.6
3918-#(C)(Iso)	Inc. 1913-S$_1$,1915-S$_1$(A,aa)	811.0	0.1	0.6

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TEST 194. BOLTING EVALUATION OF HYBRIDS, SALINAS, CA., 1993-94

96 entries x 3 replications   Planted: November 15, 1993
1-row plots, 18 ft. long   Not harvested for yield

Variety	Description	Stand Count No.	Beets/ 100' No.	% Bolting 07/05	% Bolting 08/23
US H11	L113401 (4/20/93)	25.3	141	0.0	5.3
WS-PM9		25.3	141	2.7	2.7
SS-NB3	11/9/92	26.0	145	1.3	2.6
SS-VY1	L921068 (4/13/93)	25.3	141	32.7	46.6
HH 66	rec'd 4/20/93	23.7	132	1.3	2.7
Rhizosen	L493304 (9/11/92)	24.7	137	13.6	25.9
Rhizoguard	rec'd 9/21/93	24.7	137	3.9	18.3
N303H15	2915aa x N103,N103-1 (C603)	23.3	130	2.7	12.3
R376H20	87-309H3 x R276#'s	26.0	145	6.2	14.0
R376-43-14H20	87-309H3 x R176-43-14	26.3	146	0.0	3.6
R376-43-15H20	87-309H3 x R176-43-15	26.0	145	0.0	0.0
R376-43-#(C)H20	87-309H3 x R176-43-#(C)(C76-43)	27.3	152	0.0	1.2
R376-89-5H20	87-309H3 x R176-89-5	24.7	137	0.0	2.8
R376-89-18H20	87-309H3 x R176-89-18	27.0	150	2.7	10.4
R376-89-#(C)H20	87-309H3 x R176-89-#(C)(C76-89)	27.0	150	0.0	9.9
R384H20	87-309H3 x R176-43;-89-#(C)	26.3	146	2.8	9.4
R378H20	87-309H3 x R278,R278Y	26.0	145	11.5	19.2
R380H20	87-309H3 x R280,R280Y	27.3	152	3.7	11.2
3915H20	87-309H3 x 2911,...,2915	25.7	143	1.3	3.9
3918H20	87-309H3 x 1913-#,1915-#	24.0	133	1.4	2.8
3918-#(C)H20	87-309H3 x 1913-#,1915-#(C918)	25.7	143	1.3	3.9
3913-3H20	87-309H3 x 1913-3(S_1)	25.0	139	0.0	2.7
3913-51H20	87-309H3 x 1913-51(S_1)	27.0	150	0.0	4.8
3913-70H20	87-309H3 x 1913-70(S_1)	24.0	133	0.0	1.4
3913-71H20	87-309H3 x 1913-71(S_1)	24.3	135	1.3	3.9
3909-34H20	87-309H3 x 0909-34 (C909-34)	24.0	133	1.4	6.9
3909-37H20	87-309H3 x 0909-37 (C909-37)	26.0	145	2.4	4.8
3911-4H20	87-309H3 x 2911-4 (C911-4)	24.7	137	0.0	1.4
3911-12H20	87-309H3 x 2911-12 (C911-12)	26.3	146	0.0	1.3
3911-14H20	87-309H3 x 2911-14 (C911-14)	25.0	139	2.7	6.7
3911-50H20	87-309H3 x 2911-50 (C911-50)	25.3	141	0.0	10.4
3913-5H20	87-309H3 x 2913-5	25.7	143	0.0	1.2
3913-18H20	87-309H3 x 2913-18	23.3	130	1.3	4.0
3913-22H20	87-309H3 x 2913-22	24.0	133	0.0	5.6
3913-25H20	87-309H3 x 2913-25	24.0	133	0.0	0.0
3911-1H20	87-309H3 x RZM 0911-1	25.0	139	4.2	12.0
3911-4(B)H20	87-309H3 x RZM 0911-4(B)	22.3	124	7.2	12.7
3911-24H20	87-309H3 x RZM 2911-24	25.0	139	0.0	8.0
3913-6H20	87-309H3 x RZM 0913-6	24.0	133	0.0	1.4
3913-9H20	87-309H3 x RZM 2913-9	25.0	139	0.0	0.0
3915-1H20	87-309H3 x RZM 0915-1	24.7	137	10.9	19.1
3915-4H20	87-309H3 x RZM 2915-4	19.7	109	3.3	15.4
3915-6H20	87-309H3 x RZM 0915-6	23.7	132	0.0	4.2
3915-7H20	87-309H3 x RZM 2915-7	25.3	141	1.3	1.3
3915-16H20	87-309H3 x RZM 0915-16	26.0	145	0.0	4.2
3915-22H20	87-309H3 x RZM 0915-22	27.0	150	1.2	1.2
3915-23H20	87-309H3 x RZM 0915-23	26.3	146	0.0	7.6
3915-24H20	87-309H3 x RZM 0915-24	26.3	146	5.0	7.5
3915-27H20	87-309H3 x RZM 0915-27	24.3	135	5.6	11.0
3915-34H20	87-309H3 x RZM 0915-34	21.3	119	0.0	2.9

(cont.)

Variety	Description	Stand Count No.	Beets/ 100' No.	% Bolting 07/05	% Bolting 08/23
3915-46H20	87-309H3 x RZM 2915-46	18.7	104	0.0	0.0
US H11	L113401 (4/20/93) (C603)	24.7	137	3.8	6.3
N303H50	F92-790-15CMS x N103,N103-1	25.3	141	0.0	6.5
R376H50	F92-790-15CMS x R276#'s	23.7	132	5.7	11.4
R378H50	F92-790-15CMS x R278,R278Y	25.3	141	6.6	11.8
R380H50	F92-790-15CMS x R280,R280Y	25.3	141	9.3	12.2
R384H50	F92-790-15CMS x R176-43;-89-#(C)	25.3	141	5.4	8.1
3915H50	F92-790-15CMS x 2911,...,2915	25.0	139	1.4	10.8
3918H50	F97-790-15CMS x 2913-#,2915-#(C918)	24.7	137	1.3	4.0
3909-34H50	F92-790-15CMS x 0909-34 (C909-34)	22.7	126	4.2	17.1
3909-37H50	F92-790-15CMS x 0909-37 (C909-37)	24.7	137	0.0	2.8
3911-4H50	F92-790-15CMS x 2911-4 (C911-4)	22.0	122	0.0	0.0
3911-12H50	F92-790-15CMS x 2911-12 (C911-12)	23.7	132	0.0	0.0
3911-14H50	F92-790-15CMS x 2911-14 (C911-14)	24.0	133	1.3	11.0
3911-50H50	F92-790-15CMS x 2911-50 (C911-50)	24.3	135	0.0	2.6
3913-5H50	F92-790-15CMS x 2913-5	25.7	143	0.0	1.2
3913-18H50	F92-790-15CMS x 2913-18	23.0	128	2.8	4.2
3913-22H50	F92-790-15CMS x 2913-22	22.0	122	1.4	1.4
3913-25H50	F92-790-15CMS x 2913-25	19.3	107	0.0	0.0
N303H52	F92-790-15H39 x N103,N103-1 (C306)	23.0	128	4.5	9.0
R338H52	F92-790-15H39 x R38(C)	22.0	122	4.5	4.4
R376H52	F92-790-15H39 x R276#'s	23.0	128	13.0	21.7
R378H52	F92-790-15H39 x R278,R278Y	25.3	141	5.3	9.3
R380H52	F92-790-15H39 x R280,R280Y	23.7	132	8.6	14.2
R384H52	F92-790-15H39 x R176-43;-89-#(C)	24.3	135	0.0	2.6
3915H52	F92-790-15H39 x 2911,...,2915	20.7	115	3.4	9.8
3918H52	F92-790-15H39 x 1913-#,1915-#(C918)	23.3	130	1.4	2.9
US H11	L113401 (4/20/93)	25.7	143	3.9	2.6
R384H51	F92-790-15H26 x R176-43;-89-#(C)	25.7	143	0.0	1.3
3918H39	91-762-17CMS x 1913-#,1915-#(C918)	25.3	141	0.0	2.6
R380H8	F82-546H3 x R280,R280Y	25.0	139	2.9	9.4
R380H3	F82-562HO x R280,R280Y	25.3	141	1.2	6.2
R380H26	87-309HO x R280,R280Y	25.0	139	6.7	14.6
R380H51	F92-790-15H26 x R280,R280Y	25.0	139	8.1	12.1
R380H53	F92-790-15H97 x R280,R280Y	23.7	132	6.9	15.5
R380H39	91-762-17CMS x R280,R280Y	25.3	141	4.0	10.5
R380H46	F92-790-6CMS x R280,R280Y	25.0	139	1.4	6.7
R380H54	F92-790-54CMS x R280,R280Y	25.0	139	2.7	5.2
R380H56	F92-790-54H39 x R280,R280Y	27.3	152	6.1	6.2
R380H59	2859m(C859)aa x R280,R280Y	26.0	145	3.8	11.5
R380H65	2865m(Sp)aa x R280,R280Y	25.7	143	3.9	20.8
R380H67	2867m(Sp)aa x R280,R280Y	24.3	135	9.8	16.5
R380H87	2889maa x R280,R280Y	24.0	133	8.4	13.8
R380H88	2888maa x R280,R280Y	26.0	145	10.6	19.5
R380H93	2890(C890)aa x R280,R280Y	26.3	146	0.0	3.8
R338H65	2865m(Sp) x R38(C)	26.7	148	7.9	13.9
Mean		24.7	137.2	3.2	7.8
LSD (.05)		2.8	15.3	6.4	9.9
C.V. (%)		6.9	6.9	123.3	78.7
F value		2.8**	2.8**	3.9**	4.0**

CURLY TOP EVALUATION OF SALINAS ENTRIES AT KIMBERLY, IDAHO, 1994

180 entries x 3 replications
2-row plots, 12 ft. long

Test Conducted by Terry Brown, BSDF

Variety	Description[3]	CT Grade		
		1st[1] Rating	2nd[1] Rating	CRT[2] Rating
HYBRIDS				
US H11	113401	5.0	5.0	5.6
WS-PM9	Hilleshog-MH	5.0	4.5	4.8
SS-VY1	Spreckels L921068	6.0	7.0	8.1
6770	Betaseed (30161365MN)	5.0	5.5	6.9
4454	Betaseed (2634)	5.5	7.0	7.4
Rhizoguard	9/21/93 Holly	5.5	7.0	7.6
N303H52	C790-15H39 x C603-1	5.0	6.0	6.7
R338H52	C790-15H39 x R38(C)	5.0	5.5	5.9
R376H52	C790-15H39 x R276	5.0	5.5	7.0
R378H52	C790-15H39 x R278	5.0	5.5	6.1
R380H52	C790-15H39 x R280	5.5	5.5	6.9
R384H52	C790-15H39xR176-43;-89	5.5	5.5	7.0
3915H52	C790-15H39 x 2911, 2915	5.0	5.5	6.0
3918H52	C790-15H39 x 1915-#	5.0	5.5	6.4
US H11	113401	5.0	5.5	6.3
R376H8	C546H3 x R276	5.0	5.0	6.0
R378H8	C546H3 x R278	4.5	4.5	5.5
R380H8	C546H3 x R280	4.5	5.5	6.4
R376H39	C762-17CMS x R276	5.0	4.5	6.0
R378H39	C762-17CMS x R278	5.0	4.5	6.1
R380H39	C762-17CMS x R280	5.0	5.0	6.6
3915H39	C762-17CMS x 2515, 2911	5.0	4.5	5.8
R378H50	C790-15CMS x R278	5.0	5.5	6.7
R380H3	C562HO x R280	5.0	5.5	6.7
R380H46	C790-6CMS x R280	5.0	5.0	7.1
R380H50	C790-15CMS x R280	6.0	5.0	7.7
R380H54	C790-54CMS x R280	5.0	5.5	7.3
R380H89	C790-68CMS x R280	5.0	6.0	7.7
R380H59	C859maa x R280	5.0	6.0	6.8
R380H65	2865maa x R280	5.5	6.0	7.7
R380H67	2867maa x R280	5.5	6.0	7.3
R380H93	C890aa x R280	5.0	5.5	6.9
US H11	113401	5.0	5.0	5.3
Rhizoguard	9/21/93 Holly	6.0	5.5	7.1

Variety	Description[3]	CT Grade		
		1st[1] Rating	2nd[1] Rating	CRT[2] Rating
MULTIGERM, O.P.				
U86-37	C37,86443	6.5	5.5	6.8
R309	RZM R209-#	7.0	6.5	7.9
R310	RZM R210-#	7.0	6.5	7.8
R322R4%	RZM R122R3 (B.m.)	7.5	7.0	8.6
R322R4	RZM R122R3	8.0	7.0	8.6
R322Y3%	YR-ER-PMR R122Y2	7.5	7.0	7.8
R322Y3	YR-ER-PMR R122Y2	7.0	7.0	7.7
R328	RZM 2202-#, (PI07)	6.5	5.5	6.7
R328R2	RZM R228	5.0	5.5	6.6
R332	RZM 2201-#, (R04)	6.0	5.5	7.0
R332R2	RZM R232	6.0	6.0	7.6
R334	RZM 2245-#, (R05)	6.0	6.0	7.3
R335	RZM 2442-#, (Rima)	7.5	7.0	8.1
R336	RZM 2243-#, (R22)	6.5	6.5	7.2
R337	RZM 2247-#, (WB151)	5.0	5.5	6.4
U86-37	C37, 86443	5.5	5.0	6.1
R338-1	RZM R279 x R38(C)	6.0	5.5	7.1
R338-4	R221 x R38(C), (WB 41/42)	5.5	5.5	6.9
R338-13	RZM 2243-# x R38(C)	6.0	5.5	7.0
R338-15	RZM 2247-# x R38(C)	6.0	5.5	7.1
R370	RZM R270Y	6.0	5.5	7.3
F86-31/6	Inc. C31/6	6.0	6.0	8.2
R376	RZM R276	6.0	6.0	8.0
R376Y	RZM R276Y	6.0	6.0	8.0
R376-43	RZM R276-43	6.0	7.0	8.2
R376-43-14	Inc. R176-43-14	5.5	7.0	7.7
R376-43-15	Inc. R176-43-15	6.0	6.5	8.1
R376-43-#	Inc. R176-43-#(C)	5.5	6.0	7.6
R376-89	RZM R276-89	6.0	6.0	7.2
R376-89-5	Inc. R176-89-5	6.0	6.0	7.6
R376-89-18	Inc. R176-89-18	6.5	6.5	7.6
R376-89-#	Inc. R176-89-#(C)	6.0	6.0	7.0
U86-37	Inc. C37, 86443	5.0	4.5	6.1
U86-46/2	Inc. C46/2	5.0	5.5	6.5
R378	RZM R278	6.0	5.5	7.3
R378Y	RZM R278Y	5.5	5.5	7.0
R379	RZM R279R2,R279,Y	5.0	5.5	6.9
R380	RZM R280	6.0	6.0	7.9

Variety	Description[3]	CT Grade		
		1st[1] Rating	2nd[1] Rating	CRT[2] Rating
MULTIGERM, O.P. (cont.)				
R380Y	RZM R280Y	5.5	6.0	7.6
R280-45	Inc. R080-45	5.5	6.0	7.2
R383	Y(C)rr x Rz(C)	5.5	6.0	7.4
R381-43	RZM R281-43	5.5	6.0	7.8
R381-89	RZM R281-89	5.0	6.0	7.7
R384	Inc. R176-43;-89-#	6.0	8.0	8.1
Y339	YR-ER-PMR Y139	5.0	6.5	7.5
R239C8	RZM R139C7	5.0	6.5	7.7
Y347	YR-ER-PMR Y147	6.0	6.5	8.0
R247C8	RZM R147C7	6.0	5.5	7.7
Z325	RZM Z120,2,4	6.5	6.0	7.9
Z330	RZM Z230	6.0	5.5	7.2
U86-37	Inc. C37	5.0	5.0	6.0
NR LINES & POPNS				
N203	Inc. N103 (C603)	7.5	6.5	8.3
N203-1	Inc. N103-1 (C603-1)	7.5	6.0	8.3
N244	NR-RZM N144-#(C)	8.0	5.0	7.9
N354	NR-RZM N254-#-#	7.0	5.0	7.2
N359-#	N255aa x 2915	5.0	4.5	6.3
N358-#	RZM 2915aa x N254	5.5	5.0	6.7
N303H15	2915aa x C603-1	5.5	5.5	7.1
MULTIGERM,S^f,A:aa POPNS & LINES				
5747	4747aa x A	5.0	5.0	6.4
3910	RZM 2210-#	5.5	5.5	7.3
3911	YR-ER-PMR popn	6.0	5.5	7.7
3916	RZM 2916	5.0	6.5	7.2
3917	RZM 2917-#	6.0	6.0	7.8
3915	2911Y,2915Yaa x A	5.5	5.5	7.0
3918	1913-#, 5-#aa x A	5.0	5.5	7.3
3918-#	Inc. 1913-#,5-#(S$_1$)	7.0	5.5	7.5
3909-34	RZM 0909-34	5.5	5.5	7.3
3909-37	RZM 0909-37	5.0	5.5	7.2
3911-4	2911-4Maa x A	5.5	6.0	7.4
3911-4Am	Inc. 2911-4mmA	6.0	5.5	7.1
3911-12M	2911-12Maa x A	5.0	5.5	6.5
3911-14M	2911-14Maa x A	5.0	5.5	6.9
3911-50	2911-50aa x A	5.0	5.5	7.1

Variety	Description[3]	CT Grade		
		1st[1] Rating	2nd[1] Rating	CRT[2] Rating
MULTIGERM, S[f], A:aa POPNS & LINES (cont.)				
3913-5	2913-5aa x A	6.0	5.5	7.8
3913-18	2913-18aa x A	6.0	5.0	7.2
3913-22	2913-22aa x A	6.5	4.5	6.8
3913-25	2913-25aa x A	5.0	5.5	6.9
U86-37	Inc. C37	5.0	4.5	6.3
3913-3	Inc. 1913-3(S_1)	5.0	5.5	7.2
3913-51	Inc. 1913-51(S_1)	5.0	5.5	7.8
3913-70	Inc. 1913-70(S_1)	8.0	5.5	8.5
3913-71	Inc. 1913-71(S_1)	6.0	5.5	7.7
3913-6	RZM 0913-6	5.0	5.5	6.9
3913-9	RZM 2913-9	5.0	5.5	6.9
3915-6	RZM 0915-6	5.0	5.5	7.3
3915-7	RZM 2915-7	5.0	5.5	7.0
3915-22	RZM 0915-22	5.0	5.5	7.1
3915-34	RZM 0915-34	5.0	5.5	6.9
U86-37	Inc. C37	5.0	4.5	6.4
F82-546H3	C562HO x C546	5.0	5.0	6.2
MONOGERM, S[f], A:aa POPNS & LINES				
3859	RZM 2859m	5.5	5.0	7.0
C859m	2859mmaa x A	6.0	5.5	7.2
2859mA- 1	1859mmaa x A	5.0	5.5	7.8
- 2	1859mmaa x A	5.0	5.5	6.9
- 7	1859mmaa x A	6.0	6.5	8.0
- 8	1859mmaa x A	6.5	8.0	8.8
- 9	1859mmaa x A	6.0	5.5	7.4
-10	1859mmaa x A	5.5	5.5	6.8
-14	1859mmaa x A	6.0	5.5	7.7
-21	1859mmaa x A	5.5	5.5	7.4
-23	1859mmaa x A	6.0	5.5	7.8
87-309H3	C562CMS x C309	5.0	5.5	6.8
3865	Inc. 1865-#	7.5	5.5	8.1
2865mA- 3	RZM1865mmA	8.0	5.5	8.3
- 4	RZM1865mmA	8.0	6.0	8.5
-14	RZM1865mmA	8.0	6.5	8.4
-15	RZM1865mmA	8.0	5.5	7.6
-18	RZM1865mmA	8.5	6.5	8.0
-21	RZM1865mmA	8.0	6.0	8.4
3867m	2867mmaa x A	6.0	6.0	7.1

Variety	Description[3]	CT Grade		
		1st[1] Rating	2nd[1] Rating	CRT[2] Rating
MONOGERM,S^f,A:aa POPNS & LINES (cont.)				
2867mA-1	1867,1867RmmA	6.0	5.5	6.7
2867mA-6	1867,1867RmmA	6.0	6.0	6.7
F82-546H3	C562CMS x C546	5.0	5.5	5.6
0790	$8790S_1$(C)aa x A	5.0	5.5	6.7
C890	0790mmaa x 2890	5.0	6.0	7.0
3892m	2890mmaa x A	5.0	5.5	6.9
2891mA- 4	1890mmA	5.5	6.0	7.4
- 9	1890mmA	6.0	6.5	7.2
-10	1890mmA	5.0	5.5	6.1
-16	1890mmA	5.0	5.5	7.0
-20	1890mmA	5.5	5.5	7.2
-23	1890mmA	5.5	5.0	6.6
-27	1890mmA	6.0	6.0	7.4
-31	1890mmA	5.5	5.5	7.0
-33	1890mma	6.0	6.0	7.6
-35	1890mmA	5.0	6.0	7.6
-42	1890mmA	5.0	5.5	7.1
0864- 8	9864- 8aa x A	4.5	6.0	6.6
0864-14	9864-14aa x A	5.0	6.0	7.9
0864-34	9864-34aa x A	5.0	6.0	7.7
3893m	Rzmmaa x mm,O-type	5.0	5.5	7.0
3894m	Rzmmaa x A	5.5	6.0	7.7
MONOGERM LINES				
F82-562	Inc. C562 (82196)	5.0	5.5	7.1
F82-546	Inc. C546 (82372)	4.5	6.0	6.9
C790-6	Inc. C790-6 (921189)	4.5	5.5	7.1
3790-6	Inc. O-t 2790-6	5.0	6.5	7.7
3790-15	Inc. O-t 2790-15	6.0	7.0	8.0
C790-15	Inc. C790-15 (921194)	6.0	7.0	8.0
C790-54	Inc. C790-54 (921199)	5.5	5.5	7.3
3790-54	Inc. O-t 2790-54	7.0	5.5	7.5
C790-68	Inc. C790-68 (88192)	7.5	6.5	8.0
C790-15H39	C762-17CMS x C790-15	5.5	6.0	6.6
C762-17	Inc. C762-17	5.0	5.0	5.6
C309	Inc. C309 (87672)	6.5	6.0	8.2
C546H3	C562CMS x C546	5.0	4.5	6.3
US H11	113401	5.0	5.5	6.7

CURLY TOP EVALUATION OF SALINAS ENTRIES AT KIMBERLY, IDAHO, 1994

(cont.)

Variety	Description[3]	CT Grade		
		1st[1] Rating	2nd[1] Rating	CRT[2] Rating

[1] Rated by Dr. L. Panella.

[2] CRT = Dr. C.R. Trupp's ratings. Mean of ratings by three scorers.

[3] For hybrids, US H11 used as resistant check; for O.P., C37 (U86-37) is resistant check; C546H3 is resistant check for monogerms.

80 varieties x 3 replications
1-row plots, 18 ft. long

Planted: April 28, 1994
Harvested: November 2, 1994

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia DI	Reaction % Resistant	Powdery Mildew Mean
Block 1 HYBRIDS						
US H11	113401	39.3	39.3	8.81	81.7	7.7
E840	Inc. E440, E640	35.3	41.7	90.03	5.7	7.7
E840H72	83-718HO x E440,E640	34.7	42.0	73.49	21.2	7.7
E840H8	F82-546H3 x E440,E640	37.0	41.3	38.24	48.9	7.6
N303H52	F92-790-15H39 x N103-1	35.7	37.0	64.36	23.0	7.9
R338H52	F92-790-15H39 x R38(C)	37.7	39.0	22.01	71.4	6.1
R376H52	F92-790-15H39 x R276,Y	37.0	39.7	10.22	81.1	4.8
R378H52	F92-790-15H39 x R278,Y	39.7	40.0	29.73	62.8	4.0
Block 2						
R380H52	F92-790-15H39 x R280,Y	37.3	38.0	21.70	71.0	5.0
R384H52	F92-790-15H39 x R176-43;-89-#(C)	37.0	38.7	26.16	65.3	4.2
3915H52	F92-790-15H39 x 2911,...,2915	34.7	38.0	35.11	56.9	4.3
3918H52	F92-790-15H39 x 1913-#,1915-#	36.7	37.7	16.41	75.6	4.2
R376H8	F82-546H3 x R276,Y	36.3	37.3	9.71	85.0	5.8
R378H8	F82-546H3 x R278,Y	36.7	36.0	9.39	86.4	4.8
R380H8	F82-546H3 x R280,Y	35.0	37.0	13.57	81.0	6.4
US H11	113401	35.0	39.7	6.64	85.6	7.6
Block 3						
R376H39	91-762-17CMS x R276,Y	38.0	37.3	20.06	69.6	5.6
R378H39	91-762-17CMS x R278,Y	39.0	38.7	31.21	59.3	4.9
R380H39	91-762-17CMS x R280,Y	36.7	38.0	23.64	67.2	5.7
3915H39	91-762-17CMS x 2911,...,2915	33.0	35.7	24.88	64.5	5.8
E840	Inc. E440,E640	34.0	37.7	85.38	11.6	7.9
R380H3	F82-562HO x R280,Y	35.7	36.0	14.52	76.7	6.8
R380H46	F92-790-6CMS x R280,Y	34.7	38.7	17.80	76.5	5.6
R380H50	F92-790-15CMS x R280,Y	35.0	36.0	15.61	76.0	5.2
Block 4						
R380H54	F92-790-54CMS x R280,Y	36.3	37.7	14.47	77.8	5.7
R380H89	U88-790-68CMS x R280,Y	37.0	34.0	8.78	86.4	5.4
R380H59	2859m(sp)aa x R280,Y	38.7	38.7	20.23	74.2	6.2
R380H65	2865m(sp)aa x R280,Y	34.3	35.3	14.94	78.7	7.1

TEST 2594. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS AND OPEN-POLLINATED LINES, SALINAS, CA., 1994

(cont.)

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia DI	Erwinia Reaction % Resistant	Powdery Mildew Mean
Block 4 (cont.)						
R380H67	2867m(Sp)aa x R280,Y	34.7	36.3	12.38	83.5	5.2
R380H93	2890(Sp)aa x R280,Y	38.7	38.3	14.67	77.5	6.8
US H11	113401	40.0	38.3	3.61	88.5	7.9
E840	Inc. E440,E640	33.7	38.7	83.94	12.8	7.9
Block 5 MM,O.P.						
268	Inc. 768 (US 75)	39.3	41.0	28.13	60.2	6.4
U86-37	Inc. C37, 86443	32.3	37.7	9.40	82.5	6.6
R379	RZM R279R2,Iso,Y (Rz)	37.3	38.0	12.90	82.4	6.2
R328	RZM 2202-#(C),(PI07)	37.7	38.3	8.51	87.5	7.3
R328R2	RZM R228,(PI07)	38.0	39.3	8.47	84.7	7.6
R332	RZM 2201-#(C), (R04)	38.3	39.7	9.88	85.2	5.7
R332R2	RZM R232, (R04)	38.3	39.0	6.10	87.9	7.0
R334	RZM 2245-#(C), (R05)	39.0	41.0	4.17	91.5	6.3
Block 6						
R335	RZM 2242-#(C), (Rima)	36.7	37.0	10.30	81.7	6.6
R336	RZM 2243-#(C), (R22)	38.7	37.3	31.16	61.2	7.3
R337	RZM 2247-#(C), (WB151)	37.7	40.7	17.64	77.9	5.9
R338-1,2,3(C)	RZM R279,R2,Iso,Y x R38(C)	34.7	37.0	11.57	84.5	6.9
R338-13	RZM 2243-#(C) x R39(C)	37.7	39.7	33.01	59.2	7.2
R338-15	RZM 2247-#(C) x R38(C)	36.0	35.0	23.46	66.9	7.0
R370	RZM R270Y	37.3	36.7	13.33	83.8	5.4
U86-37	Inc. C37, 86443	40.7	39.3	7.32	85.2	7.0
Block 7						
E840	Inc. E440,E640	39.0	39.0	89.23	9.1	7.7
U86-46/2	Inc. C46/2	40.0	37.3	2.30	93.2	3.8
R378(Iso)	RZM R278	38.3	40.0	22.96	68.7	3.7
R378Y(Iso)	RZM R278Y	39.0	39.7	16.58	80.4	3.7
R380(Iso)	RZM R280	39.3	38.3	17.43	72.7	5.7
R380Y(Iso)	RZM R280Y	38.0	35.7	8.35	85.2	4.9
R280-45	Inc. R080-45	38.7	38.3	5.27	93.4	4.2
R383	Y(C)rr x Rz(C)	35.0	32.0	3.41	91.2	3.6

TEST 2594. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS AND OPEN-POLLINATED LINES, SALINAS, CA., 1994

(cont.)

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia DI	Reaction % Resistant	Powdery Mildew Mean
Block 8						
F86-31/6	Inc. C31/6	34.3	36.7	5.70	90.4	3.6
R376(Iso)	RZM R276	37.7	36.7	4.21	90.9	4.8
R376Y(Iso)	RZM R276Y	36.7	38.7	7.08	85.6	4.7
R376-43(Iso)	RZM R276-43	34.7	35.7	5.28	87.5	4.6
R376-43-14	Inc. R176-43-14	38.7	41.0	8.02	87.9	4.9
R376-43-15	Inc. R176-43-15	33.0	35.7	3.12	92.9	0.7
R376-43-#(C)	Inc. R176-43-#(C)	38.7	38.7	4.85	92.0	3.8
R381-43(Iso)	RZM R281-43	37.7	36.7	4.72	90.5	5.1
Block 9						
R376-89(Iso)	RZM R276-89	39.7	41.0	15.21	80.9	5.0
R376-89-5	Inc. R176-89-5	36.0	38.7	10.97	84.8	5.3
R376-89-18	Inc. R176-89-18	38.3	39.0	7.23	88.9	3.9
R376-89-#(C)	Inc. R176-89-#(C)	39.7	37.7	6.69	90.2	5.3
R381-89(Iso)	RZM R281-89	36.3	37.7	11.02	82.6	3.4
R384(Sp)	Inc. R176-43;-89-#	35.3	38.0	14.28	80.0	4.0
E840	Inc. E440,E640	36.7	40.0	90.90	5.8	7.4
US H11	113401	37.3	39.3	11.50	83.9	7.4
Block 10						
Y339	YR-ER-PMR Y139	36.0	37.7	7.98	89.9	1.2
R239C8	RZM R139C7	35.0	34.7	23.00	71.9	1.9
Y347	YR-ER-PMR Y147	35.7	37.7	5.99	90.5	3.7
R247C8	RZM R147C7	39.0	39.3	4.74	89.7	5.4
R322R4%	RZM R122R3 (%S)	38.3	41.0	44.16	46.0	4.3
R322R4	RZM R122R3 (GSY)	35.7	35.0	47.16	46.2	5.8
R322Y3%	YE-ER-PMR R122Y2 (%S)	36.3	35.7	12.30	85.1	3.9
R322Y3	YR-ER-PMR R122Y2 (GSY)	39.7	38.0	12.73	82.6	4.0
Mean		37.0	38.1	20.64	73.2	5.5
LSD (.05)		5.0	4.8	11.68	14.0	1.1
C.V.(%)		8.4	7.8	35.09	11.9	12.4
F value		1.1NS	1.2NS	26.84**	19.0NS	16.0**

TEST 2694. ERWINIA/POWDERY MILDEW EVALUATION OF SELF-FERTILE POPULATIONS & LINES, SALINAS, CA., 1994

80 varieties x 3 replications
1-row plots, 18 ft. long

Planted: April 28, 1994
Harvested: November 3, 1994

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia Reaction DI	% Resistant	Powdery Mildew Mean
Block 1	**MM,S^f A:aa popns**					
US H11	113401	38.7	40.0	5.14	87.2	7.3
E840	Inc. E440,E640	35.7	41.7	87.19	10.4	7.8
5747	4747aa x A	37.0	36.3	6.12	88.5	6.3
9903	YR-ER-PMR 7903 (A,aa)	35.3	36.3	1.74	92.5	5.1
3910	RZM 2210-#(C)	40.3	42.3	9.89	84.1	5.4
3911	YR-ER-PMR popn-composite	40.0	35.3	0.96	96.7	2.4
3916	RZM 2916	39.0	35.3	4.59	87.1	4.3
3917	RZM 2917-#(C)	38.0	32.0	9.99	84.9	2.7
Block 2						
3915(Sp)	2911Y,...,2915Yaa x A	35.3	36.3	5.45	88.5	4.0
3918(Sp)	1913-#,1915-#aa x A	35.7	36.3	8.72	84.3	4.0
3918-#(C)(Iso)	Inc. 1913-#,1915-#S$_1$(A,aa)	33.3	37.0	2.95	94.8	4.8
Z325	RZM Z120,Z122,Z124	40.3	35.7	9.76	78.6	6.1
Z330	RZM Z230	34.7	37.0	11.68	80.4	5.9
R309	RZM R209-#(C)	38.3	40.0	5.04	91.4	4.7
R310	RZM R210-#(C)	40.7	37.0	6.93	88.4	4.3
U86-37	Inc. C37,86443	39.7	38.7	3.56	92.6	6.3
Block 3	**MM,S^f A:aa lines**					
3909-34	RZM 0909-34	26.7	25.3	4.40	88.1	1.6
3909-37	RZM 0909-37	29.7	28.3	4.01	91.8	1.8
E840	Inc. E440,E640	39.3	38.3	88.87	8.4	7.8
3911-4	2911-4Maa x A	34.3	31.3	8.45	83.4	5.0
3911-4Am	Inc. 2911-4mmA	26.7	28.0	9.30	77.7	3.0
3911-12M	2911-12Maa x A	31.0	30.3	15.91	75.1	3.4
3911-14M	2911-14Maa x A	29.7	31.0	11.79	79.1	4.3
3911-50	2911-50aa x A	36.0	31.7	1.63	94.5	3.6
Block 4						
3913-5	2913-5aa x A	36.0	35.0	6.57	88.5	4.0
3913-18	2913-18aa x A	36.7	35.7	3.36	88.2	3.9
3913-22	2913-22aa x A	30.0	35.7	4.66	84.9	4.0
3913-25	2913-25aa x A	29.0	31.3	3.74	92.1	4.3

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TEST 2694. ERWINIA/POWDERY MILDEW EVALUATION OF SELF-FERTILE POPULATIONS & LINES, SALINAS, CA., 1994

(cont.)

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia DI	Reaction % Resistant	Powdery Mildew Mean
Block 4 (cont.)						
3913-3	Inc. 1913-3(S_1)	37.0	39.7	25.24	62.5	1.9
3913-51	Inc. 1913-51(S_1)	41.0	39.3	8.39	85.8	1.7
3913-70	Inc. 1913-70(S_1)	40.3	41.3	0.34	97.5	3.6
3913-71	Inc. 1913-71(S_1)	41.3	39.3	24.31	67.3	4.2
Block 5						
US H11	113401	37.7	40.3	7.33	84.1	7.3
E840	Inc. E440,E640	36.0	36.3	91.32	5.7	7.7
3913-6	RZM 0913-6	40.0	42.0	4.53	89.9	5.3
3913-9	RZM 2913-9	34.0	35.0	8.61	82.0	4.9
3915-1	RZM 0915-1	39.7	39.7	2.71	90.9	4.1
3915-4	RZM 2915-4	36.3	35.0	9.75	4.2	4.9
3915-6	RZM 0915-6	40.0	38.0	0.85	92.3	4.2
3915-7	RZM 2915-7	33.7	33.7	6.48	84.2	2.4
Block 6						
3915-16	RZM 0915-16	37.3	37.3	21.60	68.9	2.9
3915-22	RZM 0915-22	38.7	36.3	6.44	89.4	3.8
3915-23	RZM 0915-23	36.3	35.0	4.75	91.7	3.1
3915-24	RZM 0915-24	35.3	35.0	12.32	78.2	3.8
3915-27	RZM 0915-27	38.3	42.3	10.29	79.2	3.3
3915-34	RZM 0915-34	36.7	35.7	2.87	93.5	4.9
3915-46	RZM 2915-46	35.3	35.0	5.52	91.5	4.3
E840	Inc. E440,E640	40.7	39.0	86.90	11.1	7.2
Block 7 Nema resistant						
N303H15	2915aa x N103,N103-1	36.0	37.0	5.10	87.2	7.2
N356-#(C)	NR N256 x BC_1S_3	34.3	35.3	15.88	78.3	6.6
N354	NR-RZM N254-#-#(C)	34.0	37.0	18.65	69.0	6.2
Monogerm, S^f,A:aa popns						
F82-546H3	C562HO x C546, 82460	38.0	35.0	7.26	81.5	6.8
3859(Iso)	RZM 2859m(Sp)	38.0	35.3	15.86	75.1	6.7
3859m(Sp)	2859mmaa x A	38.7	37.0	18.44	74.3	7.0
3865	Inc. 1865-#	42.7	39.7	17.87	72.1	7.4
3867m(Sp)	2867mmaa x A	32.7	33.3	21.68	63.0	5.3

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TEST 2694. ERWINIA/POWDERY MILDEW EVALUATION OF SELF-FERTILE POPULATIONS & LINES, SALINAS, CA., 1994

(cont.)

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia DI	Reaction % Resistant	Powdery Mildew Mean
Block 8						
3894m	Rzmmaa(C) x A	33.0	36.7	32.48	59.9	6.1
3893m	Rzmmaa(C) x mm, O-type	32.0	34.0	33.99	50.0	6.0
0790	8790(S₁)(C)aa x A	35.0	37.0	17.40	71.0	5.2
3890	0790mmaa x 2890	33.3	34.3	18.92	67.0	5.4
3892m(Sp)	2890mmaa x A	40.3	39.3	16.64	70.7	6.3
E840	Inc. E440,E640	34.7	41.3	85.82	9.7	7.6
monogerm lines						
2859mA(Sp)-2	1859,1859Rmma-2	34.0	32.3	41.52	44.4	5.6
2859mA(Sp)-8	1859,1859RmmA-8	26.7	29.0	41.92	55.2	5.3
Block 9						
2859mA(Sp)-14	1859,1859RmmA-4	31.3	30.0	21.09	70.0	6.7
2859mA(Sp)-21	1859,1859RmmA-21	18.0	18.0	10.39	85.2	6.7
2865mA(Sp)-4	RZM 1865,1865-#mmA-4	26.7	24.7	23.95	64.5	6.9
2865mA(Sp)-14	RZM 1865,1865-#mmA-14	20.7	21.0	42.60	46.6	5.8
2867mA(Sp)-1	1867,1867RmmA-1	30.7	29.0	22.64	60.6	4.6
2891mA(Sp)-4	1890mmA-4	33.0	34.0	7.93	82.4	5.0
2891mA(Sp)-16	1890mmA-16	33.3	32.3	28.33	56.9	6.1
2891mA(Sp)-23	1890mmA-23	31.7	31.7	16.35	79.4	5.7
Block 10						
F82-546H3	82460,C562HO x C546	37.0	37.3	8.85	83.8	6.6
91-762-17	Inc. C762-17 (10/22/91)	27.3	28.3	43.55	47.5	2.8
87-309	Inc. C309 (87672)	34.3	40.3	17.11	77.5	6.9
3790-6	Inc. O-T 2790-6-#(C)	39.3	39.3	8.99	85.0	4.7
3790-15	Inc. O-T 2790-15-#(C)	38.7	39.7	20.28	61.2	3.6
3790-54	Inc. O-T 2790-54-#(C)	44.7	46.7	9.95	83.0	4.0
F92-790-15H39	C762-17CMS x C790-15(921192)	37.0	34.0	49.78	33.4	3.0
E840	Inc. E440,E640	35.3	37.3	86.85	10.4	6.6
Mean		35.3	35.4	18.89	73.35	5.0
LSD (.05)		6.0	5.6	11.71	14.57	1.4
C.V. (%)		10.5	9.8	38.45	12.31	17.2
F value		4.9**	5.7**	28.94**	18.91**	10.7**

TEST 2194. CODED POWDERY MILDEW TEST, SALINAS, CA., 1994

261 entries x 6 replications, RCB   Planted: March 16, 1994
1-row plots, 7.5 ft. long

Entry No.	Variety	Co.	Beets/ 100'	08/05	08/12	08/18	08/25	09/01	Mean
5	Beta 4581	Beta	155	0.2	0.7	2.3	4.0	5.7	2.2
10	2BG6241	Beta	133	0.0	0.8	1.3	3.3	5.3	1.8
11	2J5324	Beta	67	0.5	0.7	2.2	5.8	7.0	2.7
17	Beta 4284	Beta	157	0.8	2.7	4.3	7.3	8.5	4.0
18	2BG6250	Beta	106	0.2	2.3	3.8	6.5	8.0	3.5
19	1BG6164	Beta	69	0.3	1.5	3.8	7.8	8.7	3.9
20	0BG6182	Beta	151	0.3	0.7	2.2	5.7	7.0	2.6
23	1BG6106	Beta	137	0.0	0.7	0.7	4.0	5.3	1.8
28	Beta 4454	Beta	171	0.7	0.8	1.2	3.3	5.7	2.1
33	0BG6109	Beta	137	0.0	1.7	4.2	7.5	8.0	3.6
42	Beta 4155	Beta	155	0.5	1.0	1.3	5.2	7.5	2.6
43	3BG6384	Beta	173	0.5	3.2	4.0	7.2	8.5	3.9
47	1J5319	Beta	89	0.5	2.5	4.2	7.2	8.5	3.8
48	0BG6173	Beta	142	0.2	1.5	3.3	6.8	8.2	3.3
51	0BG6333	Beta	146	0.0	0.7	0.7	4.5	6.5	2.1
53	1BG6146	Beta	157	0.3	1.7	1.7	5.5	8.0	2.9
54	1BG6132	Beta	135	0.0	0.3	1.5	4.5	7.3	2.3
69	1J0123	Beta	73	0.2	1.2	2.2	4.5	6.0	2.4
70	3J5128	Beta	146	0.2	2.0	3.0	6.7	7.2	3.2
85	1BG6541	Beta	168	0.0	1.7	2.8	6.2	8.3	3.2
87	2BG6334	Beta	27	0.2	0.7	1.3	4.0	6.5	2.1
88	2BG6338	Beta	157	0.0	1.5	2.5	6.0	6.8	2.8
97	9BG6276	Beta	162	0.5	1.7	3.2	6.2	7.7	3.3
99	1BG6131	Beta	140	0.5	1.8	2.0	4.3	7.2	2.7
102	1BG6426	Beta	135	0.0	1.3	2.2	5.0	7.2	2.6
103	2BG6311	Beta	168	0.0	2.0	3.5	7.3	8.5	3.6
106	Beta 4783	Beta	171	0.0	0.7	2.2	4.8	5.5	2.2
109	2J0179	Beta	122	0.2	1.0	1.7	3.7	5.7	2.1
119	0BG6450	Beta	142	0.3	1.0	2.5	6.5	7.8	3.1
121	0BG6147	Beta	157	0.7	1.7	3.7	5.3	7.0	3.1
132	0BG6178	Beta	157	0.7	2.3	3.5	7.0	8.0	3.6
135	Beta 4874	Beta	155	0.2	0.8	1.2	4.3	6.2	2.1
137	0BG6110	Beta	142	0.2	0.5	1.5	4.2	5.5	2.0
138	2BG6321	Beta	153	0.2	1.7	2.0	6.2	7.8	3.0
142	0BG6392	Beta	95	0.7	1.8	2.7	5.7	7.8	3.1

Entry No.	Variety	Co.	Beets/ 100'	08/05	08/12	08/18	08/25	09/01	Mean
						Powdery Mildew Scores			
149	0BG6330	Beta	124	0.0	0.7	1.3	4.7	7.0	2.3
151	9BG6390	Beta	137	0.3	2.5	3.8	6.3	8.0	3.6
152	2BG6101	Beta	177	0.7	3.0	3.7	6.7	7.8	3.6
154	1BG6128	Beta	84	0.0	0.7	1.7	4.7	6.7	2.3
155	2BG6039	Beta	120	0.0	0.7	2.2	4.2	6.3	2.2
161	0BG6430	Beta	140	0.0	0.7	1.0	4.3	6.3	2.1
163	Beta 4823	Beta	135	0.8	2.5	2.5	6.3	8.2	3.4
165	0BG6217	Beta	160	0.2	1.5	1.3	3.5	6.0	2.1
175	0BG6422	Beta	162	0.0	0.8	1.7	3.7	5.8	2.0
176	1BG6050	Beta	115	0.7	3.3	4.7	7.8	8.7	4.2
183	2J0152	Beta	98	0.0	0.0	0.3	3.2	5.7	1.5
187	0BG6135	Beta	149	0.0	0.0	0.7	3.3	5.0	1.5
188	2BG6052	Beta	142	0.2	0.7	2.0	4.0	6.5	2.2
190	9BG6370	Beta	122	0.0	0.0	0.8	3.0	5.0	1.7
196	2J5088	Beta	142	0.0	0.3	1.8	2.8	3.2	1.4
205	3BG6382	Beta	175	0.2	0.8	1.8	4.3	6.7	2.3
206	0BG6385	Beta	162	0.2	1.2	1.7	4.8	7.2	2.5
207	Beta 4385	Beta	188	0.2	1.0	2.2	6.5	7.3	2.9
210	0BG6560	Beta	157	0.2	2.3	3.2	5.8	7.7	3.2
214	2BG6326	Beta	153	0.5	2.7	3.8	7.0	8.8	3.8
220	2BG6068	Beta	168	0.0	1.5	1.5	5.2	7.2	2.6
232	1BG6122	Beta	115	0.0	0.5	0.7	3.2	5.0	1.6
233	Beta 4324	Beta	135	0.0	0.3	0.7	3.0	5.8	1.6
235	0BG6499	Beta	129	0.0	0.5	0.8	4.0	6.7	2.0
236	Beta 4684	Beta	120	0.0	0.5	1.2	5.0	7.5	2.4
13	HM 3029	Hill-MH	177	0.3	2.3	3.7	7.3	8.8	3.8
22	HM 3034	Hill-MH	160	0.2	1.3	3.0	6.2	8.0	3.1
24	HM 5330	Hill-MH	137	0.3	2.3	2.8	5.5	6.8	3.0
30	HM 3040	Hill-MH	191	0.2	2.3	4.0	7.2	8.3	3.7
62	HM 3044	Hill-MH	126	0.5	1.3	1.8	4.5	6.8	2.5
67	HM 3013	Hill-MH	135	0.3	3.0	3.2	6.7	8.3	3.6
74	PM 9	Hill-MH	122	0.0	0.0	0.2	1.8	5.3	1.2
90	HM 3042	Hill-MH	135	0.0	3.2	4.0	8.2	8.5	4.0
107	HM 3036	Hill-MH	151	0.0	0.2	0.0	2.5	4.3	1.2
124	HM 3025	Hill-MH	153	0.3	3.7	3.7	7.7	8.7	4.1
125	Hill 2	Hill-MH	157	0.0	0.8	2.2	4.2	5.8	2.2
130	HM 6036	Hill-MH	153	0.7	1.5	2.3	5.2	7.2	2.8
131	HM 6027	Hill-MH	137	0.7	1.8	2.8	6.0	7.5	3.2
145	HM 3041	Hill-MH	133	0.7	1.7	2.7	6.0	7.0	3.0
150	HM 3005	Hill-MH	166	0.7	1.7	2.8	5.7	7.8	3.1

TEST 2194. CODED POWDERY MILDEW TEST, SALINAS, CA., 1994
(cont.)

Entry No.	Variety	Co.	Beets/100'	Powdery Mildew Scores 08/05	08/12	08/18	08/25	09/01	Mean
153	HM 3030	Hill-MH	151	0.2	0.7	2.5	4.5	6.8	2.4
166	HM 3016	Hill-MH	171	0.7	1.3	2.5	4.3	5.7	2.4
181	HM 3012	Hill-MH	166	0.7	3.0	3.5	6.8	8.7	3.9
189	HM 3035	Hill-MH	146	0.2	0.3	1.8	1.5	4.8	1.4
212	HM 3037	Hill-MH	164	0.2	1.3	3.2	6.2	8.2	3.2
217	HM 3043	Hill-MH	153	0.2	1.5	2.7	5.5	6.5	2.8
223	HM 3032	Hill-MH	142	0.0	2.3	3.2	5.8	7.7	3.2
230	HM 3033	Hill-MH	137	0.2	0.8	1.7	5.5	6.2	2.4
241	HM 3022	Hill-MH	135	0.5	2.3	5.0	6.3	8.2	3.7
244	HM 3038	Hill-MH	131	0.0	1.2	2.2	4.0	5.7	2.2
2	93HX26	Holly	117	0.7	2.0	3.3	7.5	8.7	3.7
3	94HX18	Holly	124	0.7	1.3	2.3	6.0	7.5	3.1
7	94HX17	Holly	144	0.5	2.7	3.7	7.7	8.5	3.9
9	HH97R	Holly	126	0.3	1.5	3.2	6.7	7.8	3.3
15	HH-91	Holly	122	0.7	3.3	3.8	7.3	8.0	4.0
16	93HX32	Holly	157	0.2	3.3	4.3	8.0	8.7	4.1
21	HH-96	Holly	157	0.5	2.2	4.7	7.8	8.5	4.0
25	93HX22	Holly	129	0.3	2.8	3.3	6.8	8.0	3.6
27	93HX34	Holly	160	0.7	2.5	3.8	7.0	8.0	3.7
29	Rhizosen CT	Holly	164	0.2	2.2	3.7	6.7	8.2	3.5
31	90C-68-04	Holly	131	0.8	3.7	5.3	8.2	8.8	4.5
34	93HX09	Holly	153	1.5	3.7	5.2	8.2	9.0	4.6
37	98HX08	Holly	140	0.7	2.2	3.7	7.0	8.0	3.7
38	92HX02	Holly	135	0.2	1.7	2.2	7.2	7.8	3.2
40	Rhizoguard	Holly	135	0.5	2.5	4.7	8.2	8.8	4.1
44	HH-101R	Holly	106	0.5	1.3	3.5	7.0	8.2	3.5
49	93HX44	Holly	124	0.2	2.2	2.5	6.8	7.8	3.3
57	93HX07	Holly	142	0.5	3.5	4.5	8.2	8.8	4.4
58	Rhizosen	Holly	126	0.2	3.8	4.2	8.2	8.5	4.2
59	90-1459-0188	Holly	120	0.3	2.0	3.2	7.5	8.3	3.6
60	93HX36	Holly	151	0.2	1.3	3.3	7.5	8.5	3.5
61	94HX06	Holly	115	0.8	2.7	4.0	7.0	8.5	3.8
66	HH-95	Holly	131	0.2	0.8	2.5	5.5	7.3	2.7
76	94HX23	Holly	89	0.0	0.5	1.3	4.5	7.0	2.2
77	94HX13	Holly	153	0.2	0.7	3.0	6.8	8.7	3.3
78	94HX24	Holly	124	0.3	2.2	3.8	7.2	8.5	3.7
79	93HX31	Holly	109	0.5	3.0	4.2	7.5	8.2	3.9
81	93HX10	Holly	153	0.5	2.0	2.7	6.7	8.2	3.3
83	USC-1	Holly	131	0.0	1.0	1.5	5.5	6.8	2.5
84	89C 58-07	Holly	144	0.0	3.2	4.0	7.5	8.7	4.0

TEST 2194. CODED POWDERY MILDEW TEST, SALINAS, CA., 1994
(cont.)

Entry No.	Variety	Co.	Beets/ 100'	Powdery Mildew Scores 08/05	08/12	08/18	08/25	09/01	Mean
86	93HX42	Holly	184	0.7	2.7	4.2	7.7	8.2	4.0
89	94HX22	Holly	93	0.2	3.5	4.0	8.2	8.3	4.0
92	HH 66	Holly	140	0.3	3.5	4.8	8.7	9.0	4.5
94	HH 77	Holly	155	0.2	2.2	3.5	7.2	7.8	3.5
95	93HX13	Holly	160	0.7	3.8	5.3	8.5	8.8	4.5
96	93HX01	Holly	122	0.7	2.0	3.0	6.5	7.7	3.3
98	94HX03	Holly	135	0.5	1.3	3.0	7.0	6.7	3.1
104	HH 79	Holly	162	0.5	3.8	4.8	8.5	8.8	4.4
105	94HX05	Holly	104	0.2	2.7	3.7	7.3	8.5	3.8
110	93HX43	Holly	157	1.3	2.8	4.3	8.2	8.2	4.2
111	RhizoguardCT	Holly	137	0.5	4.0	4.3	7.8	8.8	4.3
113	94HX20	Holly	126	0.3	3.2	5.0	8.0	8.8	4.3
115	HH-84	Holly	166	0.3	3.0	4.2	8.0	8.7	4.1
116	93HX02	Holly	144	0.5	3.7	4.8	8.2	8.3	4.3
118	93HX14	Holly	142	0.8	2.3	4.0	7.5	7.8	3.8
120	HH-98	Holly	131	0.3	1.3	2.7	6.5	7.5	3.2
122	93HX29	Holly	151	0.3	1.3	2.3	6.5	8.2	3.1
123	HH-41	Holly	117	0.5	2.2	3.8	7.2	8.3	3.7
129	93HX35	Holly	157	0.8	3.7	5.0	8.3	8.8	4.4
134	93HX06	Holly	135	0.3	1.7	2.7	5.7	7.7	3.0
140	94HX09	Holly	140	0.7	2.3	3.5	7.3	8.3	3.7
141	93HX30	Holly	160	0.5	1.5	3.0	6.7	7.0	3.2
144	94HX07	Holly	137	0.2	1.7	2.2	6.2	7.0	2.9
146	91HX16	Holly	151	1.3	3.5	5.2	8.7	9.0	4.8
157	93HX25	Holly	69	0.8	2.8	3.5	5.8	8.0	3.5
159	RhizosenPlus	Holly	106	0.7	3.8	4.3	7.7	9.0	4.3
162	94HX02	Holly	133	0.8	1.2	2.5	5.8	7.7	3.1
167	94HX04	Holly	151	0.0	0.8	2.0	4.8	6.7	2.4
168	94HX10	Holly	146	0.3	1.5	3.7	7.0	8.3	3.5
172	93HX37	Holly	155	1.8	3.7	4.2	7.3	8.3	4.3
174	93HX23	Holly	109	0.7	2.2	3.3	6.5	8.0	3.5
182	93HX15	Holly	126	1.8	3.7	5.0	7.3	8.8	4.4
184	90-1459-0112	Holly	117	0.5	1.0	3.2	6.0	8.3	3.3
191	94HX19	Holly	133	0.2	1.5	2.5	5.7	7.3	2.9
193	94HX14	Holly	162	0.2	2.5	3.0	7.5	8.0	3.5
194	HH-51	Holly	137	0.0	2.3	2.8	6.3	7.3	3.2
199	94HX12	Holly	133	1.0	2.7	3.0	6.2	7.3	3.4
200	94HX08	Holly	120	1.3	3.7	4.7	7.7	8.5	4.4
202	94HX01	Holly	151	1.2	2.7	3.2	6.5	7.5	3.6
204	HH-37	Holly	171	0.8	3.0	2.8	6.8	8.2	3.6

TEST 2194. CODED POWDERY MILDEW TEST,
SALINAS, CA., 1994
(cont.)

Entry No.	Variety	Co.	Beets/ 100'	Powdery Mildew Scores 08/05	08/12	08/18	08/25	09/01	Mean
209	94HX25	Holly	129	0.3	2.5	3.0	7.0	8.2	3.6
211	94HX11	Holly	173	0.3	1.5	3.5	6.8	8.0	3.4
225	90-88C11-09	Holly	137	0.8	2.7	4.7	8.2	8.8	4.2
227	93HX33	Holly	129	1.3	3.0	3.8	7.3	8.5	4.0
231	90C 68-03	Holly	146	0.2	2.0	2.5	6.3	8.2	3.2
234	HH-38	Holly	155	0.2	0.2	1.3	4.5	7.0	2.2
237	93HX24	Holly	82	0.3	2.7	4.5	7.5	9.0	4.0
238	90C 63-04	Holly	117	0.0	2.2	3.8	7.3	8.3	3.6
239	93HX39	Holly	115	0.3	2.7	3.5	7.3	7.7	3.6
240	94HX17	Holly	67	0.0	1.0	2.0	5.3	7.7	2.7
245	89C 63-04	Holly	140	0.2	1.0	2.3	6.0	7.8	2.9
247	HH-55	Holly	131	0.8	1.5	2.0	6.5	7.7	3.1
248	93HX41	Holly	155	0.3	2.3	3.3	7.5	8.7	3.7
261	93HX38	Holly	131	0.0	1.8	2.8	5.7	7.3	3.0
1	H92524	Spreck	126	0.7	3.2	3.7	7.3	8.5	3.9
4	SS-287R	Spreck	160	0.2	1.7	3.0	6.2	7.5	3.1
6	SS-596R	Spreck	100	0.2	1.3	2.8	6.2	7.5	3.0
8	H93453	Spreck	113	0.0	2.0	3.3	6.8	8.0	3.4
12	H89303	Spreck	142	0.5	1.3	3.2	6.5	8.3	3.3
14	SS-IV1	Spreck	166	0.5	2.0	3.8	7.0	8.0	3.6
26	H90376	Spreck	149	0.2	2.3	2.8	6.2	7.3	3.2
32	H93431	Spreck	135	0.0	2.2	3.8	7.7	8.0	3.6
35	H93407	Spreck	151	0.5	2.3	4.0	7.7	8.5	3.9
36	H92659	Spreck	142	0.5	2.0	3.7	7.3	8.7	3.7
39	SS-335	Spreck	166	0.3	2.2	2.2	6.2	7.8	3.1
41	SS-289R	Spreck	168	0.3	2.5	4.0	7.8	9.0	3.9
45	H92367	Spreck	131	0.3	2.8	4.8	7.8	8.8	4.1
46	H90392	Spreck	144	1.3	4.3	6.7	9.0	9.0	5.2
50	SS-NB5R	Spreck	109	0.5	2.5	3.2	7.2	8.5	3.7
52	H88313	Spreck	175	0.0	1.5	2.7	6.5	8.0	3.1
55	SS-NB3	Spreck	100	0.0	2.0	3.2	7.2	8.5	3.5
56	H91609	Spreck	151	0.0	2.0	2.3	5.7	7.2	2.9
63	SS-502R	Spreck	122	1.0	1.8	3.7	6.7	8.2	3.7
64	H93695	Spreck	151	0.8	3.7	4.5	7.7	8.7	4.3
65	H92489	Spreck	175	1.3	1.8	3.8	7.3	8.7	3.9
68	H92482	Spreck	168	0.2	1.7	3.0	6.5	7.3	3.1
71	H89401	Spreck	135	0.2	1.7	3.0	6.2	7.5	3.1
72	H90291	Spreck	182	0.2	1.7	3.0	6.2	7.8	3.2
73	H92636	Spreck	140	0.3	2.2	3.2	6.8	8.0	3.4

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Entry No.	Variety	Co.	Beets/ 100'	08/05	08/12	08/18	08/25	09/01	Mean
				Powdery Mildew Scores					

Entry No.	Variety	Co.	Beets/ 100'	08/05	08/12	08/18	08/25	09/01	Mean
75	H90446	Spreck	146	0.3	1.3	2.7	5.8	7.2	2.9
80	SS-502	Spreck	115	0.0	2.0	3.0	6.5	7.8	3.2
82	H89349	Spreck	151	0.0	1.8	2.5	5.5	7.7	2.9
91	H93338	Spreck	120	0.2	2.5	3.0	7.8	8.3	3.7
93	H92635	Spreck	133	0.5	2.5	3.0	6.5	7.2	3.3
100	H92642	Spreck	131	0.2	2.0	4.0	7.2	8.8	3.7
101	H90451	Spreck	149	0.3	1.8	3.2	6.5	7.7	3.3
108	H92394	Spreck	162	0.5	2.3	3.5	6.8	8.2	3.6
112	H92353	Spreck	168	0.3	2.5	3.7	7.2	8.0	3.6
114	H92510	Spreck	160	0.3	1.5	2.8	6.5	7.2	3.1
117	H90917	Spreck	129	0.8	2.7	4.3	8.3	8.8	4.3
126	H92396	Spreck	164	0.8	2.8	3.3	7.0	8.5	3.8
127	H92470	Spreck	177	0.7	2.3	4.2	6.8	8.2	3.8
128	H92660	Spreck	137	0.7	2.2	3.3	6.3	8.2	3.5
133	H90636	Spreck	153	0.5	2.8	4.0	7.2	8.2	3.9
136	H92372	Spreck	155	0.0	2.3	2.7	6.2	8.3	3.3
143	H92366	Spreck	168	0.7	2.5	4.2	7.7	8.2	3.9
147	H93887	Spreck	162	0.0	1.3	3.3	7.0	8.3	3.3
148	H90448	Spreck	164	0.5	1.3	1.8	5.7	6.8	2.7
156	H93392	Spreck	137	0.8	2.5	3.7	6.3	8.2	3.6
158	H92570	Spreck	146	0.2	4.0	4.8	7.8	9.0	4.3
160	SS-780R	Spreck	122	0.2	2.0	3.0	5.8	7.7	3.1
164	SS-334R	Spreck	135	0.2	2.7	3.8	7.5	8.8	3.8
169	H92631	Spreck	166	0.3	2.2	3.2	6.5	7.8	3.4
170	H93432	Spreck	182	0.0	2.2	3.2	7.2	7.8	3.4
171	SS-781R	Spreck	100	0.7	2.3	3.3	6.7	8.2	3.6
173	SS-VY1	Spreck	157	0.2	2.0	2.7	5.5	6.8	2.9
177	H93365	Spreck	149	0.2	2.2	3.7	6.8	8.3	3.6
178	H90631	Spreck	149	0.0	1.8	3.2	5.5	7.3	3.0
179	SS-IV2	Spreck	184	0.7	3.5	3.8	7.3	7.8	3.9
180	SS-NB2R	Spreck	126	0.3	3.7	4.2	7.5	8.3	4.1
185	H92376	Spreck	157	0.2	1.2	2.8	6.8	7.8	3.2
186	H93834	Spreck	109	0.2	2.3	2.7	5.7	7.8	3.1
192	SS-NB2	Spreck	151	0.5	3.2	3.3	7.0	8.3	3.8
195	H93572	Spreck	113	0.5	1.5	3.5	6.8	8.0	3.4
197	H92338	Spreck	168	0.7	2.5	2.8	6.5	7.5	3.4
198	SS-334	Spreck	155	1.3	2.5	2.8	6.5	7.5	3.6
201	H92528	Spreck	151	1.3	3.2	3.8	8.0	8.7	4.3
203	SS-NB2R2	Spreck	133	1.7	3.7	4.0	7.5	8.5	4.4
208	H92397	Spreck	166	0.2	2.2	2.5	5.7	7.5	3.0

Entry No.	Variety	Co.	Beets/ 100'	Powdery Mildew Scores					
				08/05	08/12	08/18	08/25	09/01	Mean
215	SS-NB5	Spreck	160	0.2	2.0	3.5	6.8	8.2	3.5
216	H91264	Spreck	155	0.0	0.0	0.3	2.5	4.5	1.3
218	SS-595R	Spreck	140	0.3	2.2	2.3	5.8	7.5	3.1
219	SS-293R	Spreck	171	0.0	1.0	1.5	5.2	7.3	2.5
221	H92488	Spreck	175	0.2	3.2	3.3	6.7	8.0	3.6
222	H93364	Spreck	122	0.2	3.7	4.3	7.5	8.2	4.0
224	H92559	Spreck	155	0.2	3.2	4.5	7.8	8.7	4.1
228	H91601	Spreck	164	0.7	1.7	3.2	7.2	7.7	3.4
242	H90472	Spreck	135	0.0	1.2	3.0	4.0	7.5	2.6
243	H92370	Spreck	151	0.2	2.0	4.0	7.2	8.3	3.6
246	H93346	Spreck	91	0.0	0.5	1.3	4.7	6.0	2.1
249	H92579	Spreck	164	0.2	1.8	3.7	6.3	7.5	3.3
139	US H11	Check	129	0.7	2.8	4.7	8.2	8.8	4.2
213	US H11	Check	133	0.3	2.3	4.5	7.8	9.0	4.0
226	US H11	Check	113	1.0	2.8	3.8	8.3	8.8	4.1
229	US H11	Check	109	0.8	3.3	3.5	8.2	8.7	4.2

Checks included by USDA

Entry No.	Variety	Co.	Beets/ 100'	08/05	08/12	08/18	08/25	09/01	Mean
250	US H11	USDA	168	0.8	2.5	4.2	6.7	8.8	3.9
251	US H11	USDA	140	0.3	2.7	3.8	8.2	8.8	4.0
252	US H11	USDA	140	0.8	3.0	4.7	8.3	8.8	4.3
253	US H11	USDA	142	0.2	2.2	3.8	7.3	7.8	3.6
254	WS-PM-9	USDA	153	0.0	0.3	0.8	2.2	4.5	1.3
255	WS-PM-9	USDA	120	0.0	0.2	0.8	2.7	5.7	1.6
256	WS-PM-9	USDA	126	0.0	0.5	1.2	4.2	5.2	1.9
257	WS-PM-9	USDA	137	0.0	0.2	1.2	2.8	4.5	1.4
258	Y039	USDA	144	0.0	0.0	1.0	1.8	4.0	1.1
259	Y039	USDA	100	0.5	0.5	0.3	3.2	5.2	1.6
260	Y039	USDA	135	0.0	0.0	0.8	2.5	4.3	1.3
Mean			140.3	0.4	2.0	3.0	6.3	7.6	3.2
LSD (.05)			36.6	0.9	1.7	1.5	1.5	1.2	0.8
C.V. (%)			23.1	219.3	76.7	44.2	21.3	14.2	22.6
F value				3.4**	1.2*	2.6**	4.5**	7.8**	6.4** 7.2**

Footnote: Mean PM calculated from six weekly ratings made 07/27, 08/05, 08/12, 08/18, 08/25, and 09/01. Scores for 07/27 are not listed. Powdery mildew scored on a scale of 0 to 9; where 9 = 90-100% of visible leaf area infected. Mean value (area under disease progress curve) most likely represents varietal reaction and differences among varieties. Scoring was stopped when most susceptible entries and US H11 started having lower values.

TEST 5094.   1994 EVALUATION OF AMES PI #'s FOR VIRUS YELLOWS AND RHIZOMANIA
SALINAS, CA., 1994

56 entries x 3 replications
1-row plots, 10 ft. long

Planted: May 23, 1994
Natural infection to BWYV
Harvested: December 9, 1994

P.I.# Variety	#1 Stand Count	#1 End Use[1]	#5 Pop. Unif.[2]	#12 Leaf Blade Pigment[3]	#19 Petiole Color[4]	#37 Bolting Tend.[5] 7/14	#37 Bolting Tend.[5] 8/11	#61 BWYV[6] 8/24	#66 P.M.[7] 9/26	#74 RZM Score[8]
PI 140353	64	6	2	3	4	3	3	4.0	1.7	s
PI 140355	69	1	3	3	1	2	3	0.7	2.3	s
PI 140359	58	7	3	3	6	3	3	4.0	0.3	s
PI 142812	52	7	3	3	6	2	2	0.0	1.0	s
PI 164671	68	6	1	6	4	1	1	2.3	-	-
PI 164968	66	2	3	3	3	2	2	0.0	0.0	s
PI 540557	61	6	1	2	1	1	1	3.0	0.0	s
PI 540558	59	6	1	2	4	1	1	3.0	-	s
PI 540559	67	6	3	2	4	3	3	5.0	4.0	s
PI 540561	60	6	1	2	4	3	3	3.0	2.0	s
PI 540564	57	6	1	2	4	1	1	4.3	0.0	s
PI 540568	58	6	1	2	4	3	3	3.7	-	-
PI 540575	58	6	1	3	4	2	3	1.7	4.0	seg
PI 540578	61	6	2	2	4	3	3	3.7	2.0	s
PI 540580	40	6	1	2	4	3	3	5.0	4.0	s
PI 540582	53	6	1	2	4	3	3	3.7	0.0	s
PI 540584	62	7	1	2	4	2	3	2.0	6.3	seg
PI 540585	53	6	1	2	4	2	3	1.0	6.0	seg
PI 540589	48	7	2	2	4	3	3	3.0	6.0	seg
PI 540590	47	6	2	2	4	3	3	3.0	3.5	seg
PI 540592	47	6	1	2	4	3	3	2.0	4.3	seg
PI 540594	59	6	2	2	4	3	3	3.0	3.3	seg
PI 540595	71	6	2	2	6	3	3	4.3	6.0	seg
PI 540618	55	6	1	2	4	3	3	0.3	2.7	seg
PI 540625	65	6	1	2	4	3	3	2.0	4.7	seg

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TEST 5094. 1994 EVALUATION OF AMES PI #'s FOR VIRUS YELLOWS AND RHIZOMANIA SALINAS, CA., 1994

(cont.)

P.I.# Variety	Stand Count	#1 End Use[1]	#5 Pop. Unif.[2]	#12 Leaf Blade Pigment[3]	#19 Petiole Color[4]	#37 Bolting Tend.[5] 7/14	8/11	#61 BWYV[6] 8/24	#66 P.M.[7] 9/26	#74 RZM Score[8]
PI 540630	65	6	1	2	6	2	3	1.7	4.7	seg
PI 540636	66	6	1	2	4	3	3	4.0	3.0	seg
PI 540637	63	6	1	2	4	3	3	2.0	6.0	seg
PI 540638	64	6	1	2	4	3	3	2.3	6.5	seg
PI 540640	65	6	1	2	4	3	3	1.3	4.0	seg
PI 540641	67	6	1	2	4	3	3	2.7	3.7	seg
PI 540642	63	6	1	2	4	3	3	2.7	6.3	seg
PI 540643	60	6	1	2	4	2	3	1.3	3.3	seg
PI 540646	59	6	1	2	4	2	3	2.7	4.3	seg
PI 540668	50	6	1	2	4	2	2	0.0	3.0	seg
PI 540675	59	6	1	2	4	2	2	0.0	1.3	seg
PI 540689	76	6	2	2	4	3	3	5.0	8.0	seg
PI 540690	62	6	2	2	4	3	3	4.3	3.5	seg
PI 540692	62	6	1	2	4	1	1	2.3	-	s
Ames 2644	60	5	1	1	4	2	2	0.0	6.7	s
Ames 2655	32	1	1	1	6	2	2	0.0	3.7	s
Ames 2658	56	1	2	2	1	2	2	0.0	6.7	s
Ames 2663	45	7	1	2	1	2	3	0.0	0.0	s
Ames 2684	41	2	1	4	3	2	2	0.0	2.7	s
Ames 3038	63	1	1	2	1	2	2	0.0	3.0	s
Ames 3059	56	1	1	2	1	2	2	0.0	6.0	seg
Ames 3060	65	7	1	1	1	2	2	0.0	6.3	s
Ames 3061	57	1	1	1	1	2	2	0.0	4.0	s
Ames 3062	64	1	1	2	1	2	2	0.0	2.3	s
Ames 8448	62	6	2	2	4	3	3	4.3	4.7	seg

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TEST 5094.   1994 EVALUATION OF AMES PI #'s FOR VIRUS YELLOWS AND RHIZOMANIA
SALINAS, CA., 1994

(cont.)

P.I.# Variety	Stand Count	#1 End Use[1]	#5 Pop. Unif.[2]	#12 Leaf Blade Pigment[3]	#19 Petiole Color[4]	#37 Bolting Tend.[5] 7/14	8/11	#61 BWYV[6] 8/24	#66 P.M.[7] 9/26	#74 RZM Score[8]
Checks										
R223	59	6	1	2	4	2	2	0.0	5.7	seg
R317	51	6	2	2	4	2	3	0.0	4.7	seg
US H11	67	5	1	1	1	2	2	0.0	6.3	s
R139C7	62	7	1	2	1	2	2	0.0	4.0	seg
R376Y(Iso)	62	7	1	2	1	2	2	0.0	6.0	seg
SP7622-0	65	1	1	2	1	2	2	0.0	5.3	s

[1] #1 End Use based upon field plot appearance where: 1 = chard; 2 = DDR-like; 3 = DDR, chard, spinach; 4 = fodder; 5 = sugar; 6 = wild beet type; 7 = mixed; 8 = annual.

[2] #5 Population Uniformity: 1 = all plants alike; 2 = uneven different types; 3 = mixed, green, red, yellow, high, low, large leaves, small leaves, etc.

[3] #12 Mature Leaf Blade Pigmentation: 1 = light greed (chard); 2 = green; 3 = red & green; 4 = red; 5 = mutant.

[4] #19 Petiole Color: 1 = green; 2 = pink; 3 = red; 4 = candy stripe; 5 = yellow, 6 = mixed.

[5] #37 Bolting Tendency without cold induction: 1 = B-(annual) = 100%; 2 = bb(biennial) - 0%; 3 = B:bb(mixed) 1-99%.

[6] #61 Beet Western Yellows (BWYV): 0 = immune; 1 = very resistant; 3 = resistant; 5 = intermediate; 7 = susceptible; 9 = highly susceptible based upon yellowing of leaves. One reading 8/24/95.

[7] #66 Powdery Mildew classified 9/26/94 on a scale of 0 to 9 where 9 = 100% of leaf area mildewed.

[8] #74 Rhizomania classified at time of harvest 12/9/94: S = susc.; Seg = segregating; R = resistant.

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Improved Soil Test for BNYVV Using Molecular and Immunological Probes.
BSDF project #280
G. C. Wisler, H.-Y. Liu, and J. E. Duffus

Current assays for rhizomania, caused by beet necrotic yellow vein virus (BNYVV), involve growing sugar beet seedlings in soil samples for 6-8 weeks, followed by an ELISA test for the presence of the virus. This procedure has some drawbacks because of the amount of time and greenhouse space required to make a diagnosis. However, the difficulties in making an accurate diagnosis of this disease have necessitated such a test. The problems associated with accurate diagnosis of rhizomania infested soil are due to several factors. The resting structures of the vector, *Polymyxa betae*, are extremely durable and survive in the soil for years, often at low levels, until the conditions of water, temperature, and suitable host are appropriate for germination. Another complicating factor in diagnosis is that the virus does not typically move systemically in the host, and remains unevenly distributed in sugar beet roots. Therefore, sampling of infected tissue can influence the accuracy of an ELISA test. Recent studies (see BSDF # 203) have shown that BNYVV is in some ways distantly related to several other furoviruses of sugar beet, and that sensitive assays based on polyclonal antisera to the coat protein of BNYVV and other furoviruses related to the beet soil borne mosaic virus-1 and-2, originally collected from Texas, can show low levels of cross-reactivity, and thus confuse diagnosis. Because of the importance of correct diagnosis of BNYVV, efforts have been made to improve the ability to test for BNYVV.

Ultimately, our goal is to be able to sample directly from the soil for BNYVV in an accurate and sensitive test, whether the soil is fallow, or is planted in beets or an unrelated crop. To achieve this goal, a number of steps must be taken. First, the various serological and molecular (nucleic acid) probes must be analyzed for their specificity to BNYVV or the related furoviruses previously described. Monoclonal antibodies to BNYVV have been shown (see BSDF # 203) to be completely specific to BNYVV in western blots, as well as polyclonal antisera to a small portion of the BNYVV coat protein. Western blot analysis is extremely helpful in making accurate diagnosis of BNYVV and distinction from BSBMV-types because the correct molecular weights can be determined provided appropriate controls are also tested. Unfortunately, western blots are not suited to large numbers of samples. This technique is being currently used in both Salinas and at University of Nebraska to confirm questionable results that can arise in ELISA tests.

Complimentary DNA (cDNA) clones to each of the four RNA's from BNYVV have been obtained from the American Type Culture Collection (ATCC) and have been used to produce nonradioactive probes. These

probes have been used in hybridization studies to determine their specificity to the BNYVV isolates and their possible relationship to the related furoviruses of sugar beet from the U.S.A. Figure 1 shows an agarose gel with two isolates of BNYVV, one each from California and Idaho, the two original isolates of BSBMV from Texas, and two isolates from Nebraska which are serologically identical to BSBMV. It is clear that the two Texas isolates are quite different in their RNA pattern from both the BNYVV isolates as well as the two new isolates from Nebraska. This gel was transferred to a nylon membrane and then sequentially hybridized with the probes to RNA-1, -2, -3, and -4. Results from these tests are summarized in Figure 2. Results from these hybridizations show: (1) the RNA-1 probe strongly reacts with both BNYVV isolates, and weakly reacts with RNA-1 of the other furoviruses (2) the RNA-2 and RNA-3 probes are completely specific to the RNA-2 from the BNYVV isolates, and (3) RNA-4 was not found in either BNYVV isolate tested, but reacted with the third RNA band from the BSBMV-1 and with an RNA band from the Nebraska 10 isolate. This shows that the probes to RNA-2 or-3 may be very useful in dot blot analyses from soil samples to give a highly specific and sensitive test.
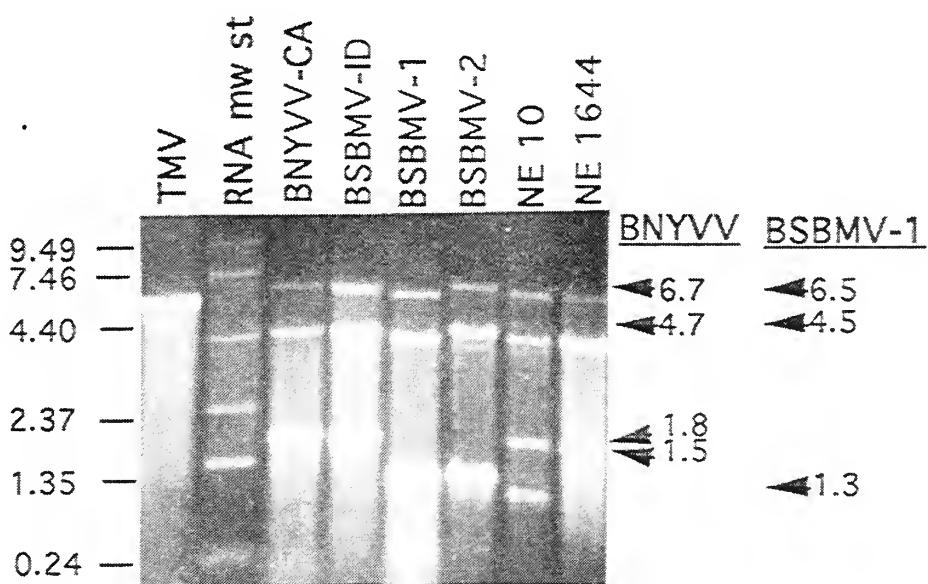
Figure 1. Agarose gel showing the RNA pattern of several furoviruses of sugar beet. The samples are listed from left to right; tobacco mosaic virus (TMV), RNA molecular weight standards, BNYVV from CA and ID, BSBMV-1 and -2 from TX, and two isolates from NE which are serologically identical to BSBMV. Arrows indicate the number of bases for the respective RNAs of BNYVV and BSBMV-1. Note that, although NE 10 and NE 1644 are serologically identical to BSBMV-1 and -2, the RNA pattern is more like that of BNYVV.
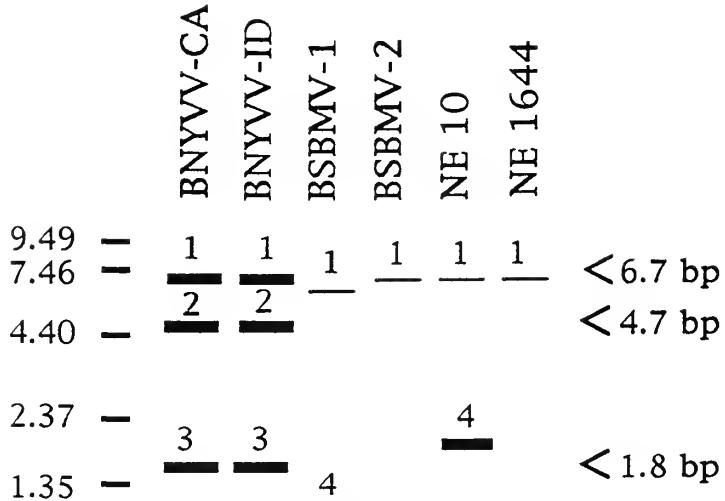
Fig. 2. Results from hybridization experiments using nonradioactively labeled probes to the RNA-1, -2, -3, and-4 of BNYVV. The gel in Fig. 1 was transferred to a nylon membrane and sequentially hybridized with each BNYVV RNA probe. The numbers above the RNA bands refer to the RNA probe of BNYVV which reacted with the respective RNA band for each isolate. Bold lines indicate strong reactions and thin lines indicate weak reactions. Arrows indicate the number of base pairs for BNYVV RNAs.

Another type of test called immunocapture-PCR (polymerase chain reaction) has been used to detect BNYVV in root samples. Briefly, the virus is captured on wells of an ELISA plate, removed with a specific buffer treatment, and then used in the polymerase chain reaction to identify a particular region of the genome. This technique has been used to detect low numbers of particular antigens. Results of this test are shown in Figure 3. The bands at 1000 base pairs (bp) are specific for BNYVV. Further testing will be done to determine the sensitivity of this technique.
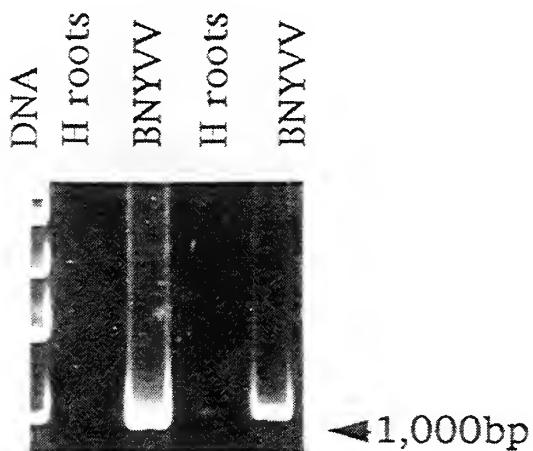
Fig. 3. Results from immunocapture-PCR. DNA mw standards are on the left. **H roots** refers to healthy sugar beet roots, and **BNYVV** roots refer to BNYVV-infected roots. Arrow is aligned with the BNYVV PCR product.

The primary obstacle to assaying directly from the soil for BNYVV is the vector, *P. betae*. In order to effectively test for BNYVV from the soil, it must be detected from within the structures of *P. betae*. A cDNA clone has been obtained from Dr. E. S. Mutasa of Broom's Barn, UK, which is specific to *P. betae*. A nonradioactive probe has been prepared from this clone, and is being used to detect the nucleic acid of the *P. betae*, either in cystosori, zoosporangia, or zoospores from sugar beet roots. This research is in its early stages, but eventually we hope to be able to release zoospores, trap them on a nylon membrane, and use the cDNA probe to detect the vector. Once we can detect the vector, we will determine the sensitivity of such a test. If we can determine the sensitivity of this test for detection of zoospores, we can then use the specific BNYVV cDNA probes to RNA-2 and -3 to compliment this test. These types of assays have been used to detect extremely low numbers of genes (Bennett et al., 1993; Lanzillo, 1991, and Tsai et al, 1993) in a variety of organisms. However, in each case they have detected the target virus or organism directly. Our case with Rhizomania is different, in that the organism in question resides inside another. This may require short baiting periods and/or specific temperature regimes to induce zoosporangial release.

Progress has been made towards the goal of improving the soil test for Rhizomania. We know that monoclonal antibodies are capable of specifically diagnosing BNYVV and distinguishing it from the related furoviruses of sugar beet. We also have shown that both RNA-2 and -3 of BNYVV are specific to BNYVV only, and show no homology with the other furoviruses, and these may be very useful in dot blot assays from soil tests. We have prepared nonradioactive probes to the vector of BNYVV and are now evaluating them for application towards a more accurate and sensitive test for rhizomania directly from soil.

Evaluation of Photosynthetic Parameters in the Selection of Varieties with Improved Rates of Sugar Production

Adel Zayed and Norman Terry

Department of Plant Biology, 111 Koshland Hall, University of California, Berkeley, CA 94720

Introduction:

Light energy is absorbed by chlorophyll molecules for photosynthesis. However, portions of the absorbed light are always lost as heat or by re-emission as fluorescence. Since these decay processes of excited chlorophyll are competitive, the intensity of the emitted fluorescence is considered to be a sensitive indicator of the leaf's photosynthetic activity.

Chlorophyll fluorescence originates mainly from chlorophyll molecules associated with Photosystem II (PSII). Hence, fluorescence yield reflects the properties of excitation and energy conversion at PSII. The function of PSII is known to be affected by various environmental stresses and very good correlations have been found between leaf fluorescence characteristics and several stresses, e.g., photoinhibition of photosynthesis, frost-killing temperature, high temperature, . and drought. Recent studies have proven that chlorophyll fluorescence provides a rapid non-destructive method for studying heat and drought stress tolerance in plants (Ogren, 1990; Prange et al., 1990; Jefferies, 1992; Smillie, 1992). However, due to the functional connection of PSII to the other components of the photosynthetic apparatus, fluorescence yield is considered to be a sensitive indicator not only of environmental stress but also of the state of activity of the entire photosynthetic process (Schreiber and Bilger, 1987). Recent improvements in fluorescence techniques, particularly the development of the pulse modulation chlorophyll fluorometer, have served to increase the value of fluorescence as a nonintrusive method of monitoring photosynthetic events and judging the physiological state of the plant (Krause and Weis, 1991).

There is eveidence that sucrose storage and partitioning are physiologically linked to photosynthetic rate (Wardlaw, 1990) and that changes in the latter are reflected by changes in fluorescence (see also Krause and Weis, 1991). Krause and Weis (1991) indicated that the F_V/F_m* ratio has become an important and

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* Abbreviations: F0, fluorescence intensity of dark adapted leaf with measuring beam of negligible actinic intensity. Fm, maximum fluorescence obtained with dark adapted leaf upon application of saturating light pulse. Fv, variable fluorescence at any given time during induction. Fv/Fm, variable fluorescence/maximum fluorescence. (Fv)s, maximal variable fluorescence at any given time during induction observed with application of a saturation pulse.

easily measurable parameter of the physiological state of the photosynthetic apparatus in intact plant leaves. Furthermore, Bolhàr-Nordenkampf and Öquist (1993) have shown (by calculations of rate constants for competing decay reactions at F_O and F_m) that this ratio is proportional to the quantum yield of overall photosynthesis. They also indicated that the correlation between F_v/F_m and photosynthetic rate is highly reproducible at least in the case of photoinhibition. Our research is the first to show that F_v/F_m is also strongly correlated with storage root sucrose concentration and content, i.e., that chlorophyll fluorescence is linked to the storage of sucrose as well as to its production.

The overall goal of this project is to identify physiological parameters in young plants which can serve as markers to facilitate the selection of superior-yielding sugar beet genotypes. Specifically we have chosen chlorophyll fluorescence since our results show that the sucrose concentration and content of storage roots are linked physiologically to chlorophyll fluorescence. Large numbers of very young plants can be screened very quickly using the highly portable and sophisticated pulse modulated PAM fluorometer. The idea we wish to test is that pulse-modulated fluorescence can be used as an innovative screening method for the rapid identification of plants with superior yield potentials. The long-term goals of our research are 1) to develop the fluorescence approach into a simple and easily-workable technique for the rapid selection of high yielding genotypes, and, 2) to apply the technique for the actual development of new better-yielding varieties. In previous years, we found two fluorescence parameters, $(F_v)_s$ and F_v/F_m, which were highly promising as yield predictors, i.e., selection for these parameters in a population of young plants was successful in predicting which plants would later have high sucrose yields or percentage sucrose.

Progress to Date:

During the 1993 growing season, we sought to optimize the experimental procedure for using pulse-modulated fluorescence to develop new high-yielding genotypes. Our objectives were to: 1) increase the size of the selection sample as well as that of the total population screened, 2) to provide growing conditions which minimized competition between plants for light and nutrients, and 3) to increase the length of time between fluorescence measurement and harvesting (particularly for root sugar content).

The 1993 greenhouse experiment permitted us to increase the sample size at the time of selection and the total size of population screened, and to increase

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$(F_v)_m$, maximal variable fluorescence of dark adapted sample. qE, energy-dependent quenching. qQ, photochemical quenching.

illumination and mineral nutrient supply. However, we also encountered unanticipated setbacks in that plants wilted after transfer from the growth chamber to the greenhouse, suffered damage following an unusual heat wave, and some plants developed fungal infections of their roots. The faster-growing plants were more prone to damage than their slow-growing counterparts and we believe that this, along with increased variability, reduced our chances of obtaining good correlations of sugar yield with fluorescence.

During the 1994 growing season we continued to carry out the experiments inside a computer-controlled greenhouse which maintains temperatures and irradiance within certain defined limits. This facility enabled us to grow the plants in a single controlled environment and to illuminate the plants at high light intensities (up to 2000 μmol m^{-2} s^{-1}). In 1994's experiment we avoided the difficulties we encountered in 1993 hydroponic experiment by conducting the whole experiment, from seed germination to harvest, in pots filled with potting mix. By this means we eliminated the transplanting shock, root cracking and root fungal infection (in the 1993 experiment, the storage roots cracked when they expanded into the lids of the nutrient solution container; this led to fungal infection). The fluorescence measurements were carried out in the greenhouse daylight conditions. This required the use of special adapters to dark-adapt portions of the intact leaves *in situ* before measuring fluorescence emission under daylight illumination.

Three weeks after sowing seeds directly into the soil, chlorophyll fluorescence of the attached leaves was measured using the pulse modulation chlorophyll fluorometer Model PAM 101 (H. Walz, Effeltritch, FRG). At the end of the fluorescence measurement period (5 days), the 30 plants exhibiting the highest values and the 30 plants with the lowest values of each of the two fluorescence parameters, $F(v)_s$ and F_v/F_m, were selected (giving a total of 96 plants) and transferred into larger pots (each pot containing approximately 10 kg soil mix). The plants were allowed to grow in these pots for another 6 weeks after which they had reached sufficient size for harvesting. At harvest, we measured storage root sugar yield and percentage storage root sucrose as well as fresh and dry weights of plant parts. All the 96 plants were tested for statistical correlations between sucrose percentage or root sugar yield, with $F_{(v)s}$ or F_v/F_m as well as other fluorescence parameters that were measured at the early young seedling stage of growth.

Results:

Our results show very highly significant statistical correlations between root sugar levels and fluorescence yield. For example, there is a very highly significant correlation ($P < 0.001$) between F_v/F_m and storage root sucrose concentration. Young plants selected for low values of F_v/F_m subsequently

exhibited storage roots with high sugar concentrations ($P < 0.001$) and high total sugar yield ($P < 0.05$) (Fig. 1a,b). Similarly, young plants selected for low values of $F_{(v)s}$ developed storage roots with high sugar concentrations ($P < 0.05$) and high total sugar yield ($P < 0.05$).

Other significant correlations were obtained when fluorescence parameters other than $F_{(v)s}$ or F_v/F_m were considered. We found that high storage root sugar concentration correlated negatively with low values of F_v ($P < 0.01$) (Fig. 2a), $F_v/(F_v)_m$ ($P < 0.001$) (Fig. 3a), F_0+F_v ($P < 0.01$), and q_Q/q_E ($P < 0.05$), and correlated positively with high values of $q_E \cdot (F_v)_m$ ($P < 0.01$), q_Q ($P < 0.001$), q_E ($P < 0.01$). Total storage root sugar yield correlated negatively with F_v (Fig. 2b), $F_v/(F_v)_m$ (Fig. 3b), q_Q/q_E, and correlated positively with q_E and $q_E \cdot (F_v)_m$.

Furthermore, when we selected the five plants exhibiting the highest values and the five plants with the lowest values (out of the 96 selected plants) for each of the fluorescence parameters measured, we found that the average sugar concentration and total sugar yield per plant differed significantly between the two groups of plants (Fig. 4a,b). For instance, the average sugar concentration for the five plants with the highest and five plants with the lowest values of F_v/F_m was 9.38% ± 1.27 and 11.48% ±0.72, respectively.

Conclusions:

These results are striking in that they show that fluorescence yield is very highly correlated with storage root sucrose concentration. This is the first time that there has been such an unequivocal demonstration that leaf (chlorophyll) fluorescence depends on the ability of the plant to store sucrose in its storage root as well as on its ability to produce sugar photosynthetically in the leaf. These results are exciting in that they show that leaf fluorescence can accurately predict which individuals in a population can store sugar at high concentrations in storage roots. By screening sugar beet genotypes which are known to produce large storage roots, it should be possible to develop new genetic lines with superior yield potentials. Specifically, selection for low values of F_v/F_m will identify those individual plants which will most probably have high sugar concentration in their storage yield at harvest.

Future Plan:

The data we obtained to date prove that the fluorescence technique can be used for the rapid selection of superior-yielding individual plants. Thus, we have fulfilled our first long-term goal. Our next step is to apply this technique for the actual development of new better-yielding varieties. We plan therefore, to screen

a large population of sugar beet genotypes (of appropriate genetic background) at the seedling stage using the three fluorescence parameters that were most correlated with sugar content in roots during the 1994's greenhouse experiment, i.e., F_v/F_m, F_v, and $F_v/(F_v)_m$. The selected plants will then be grown until maturity and used for obtaining new genetic lines with improved sugar yields.

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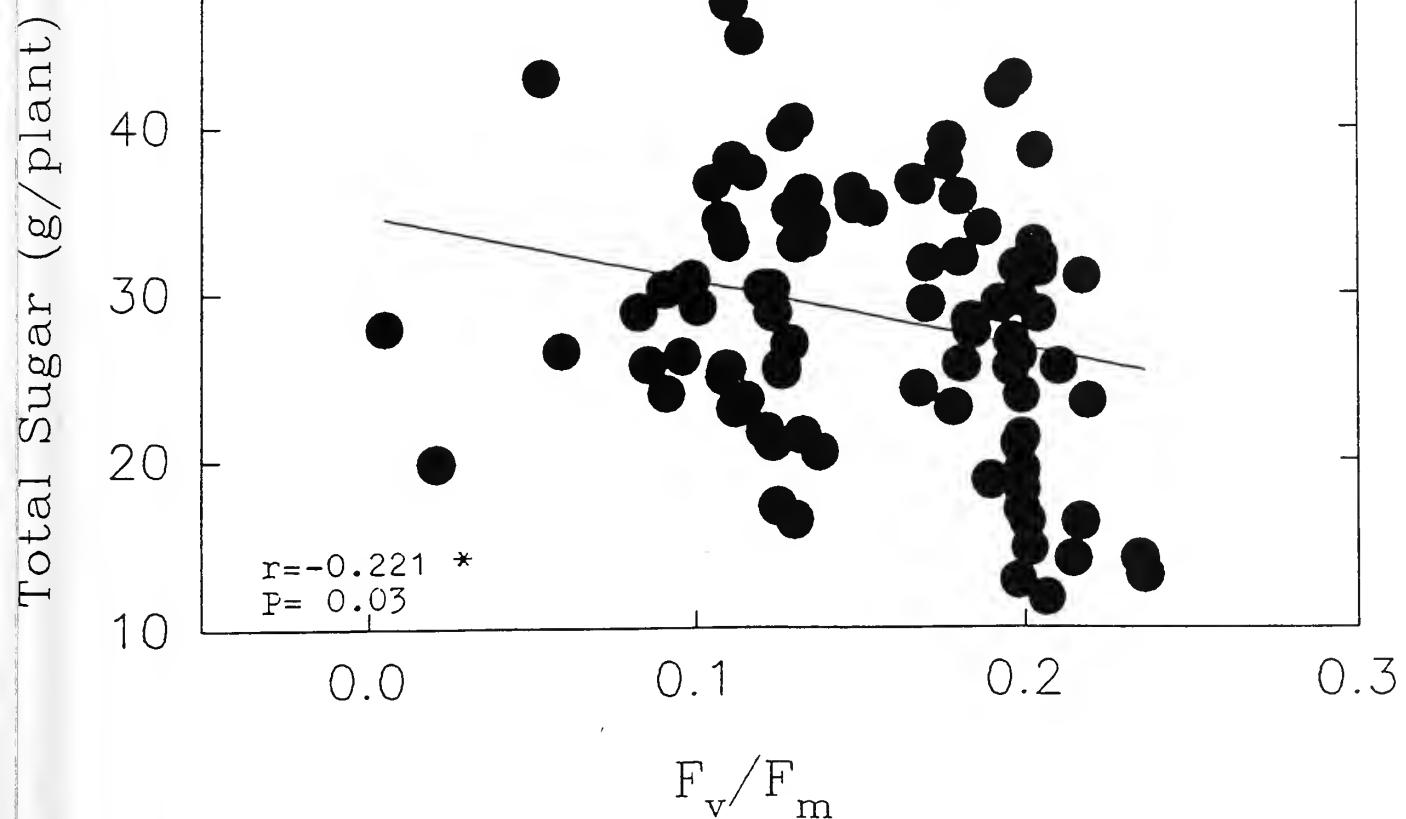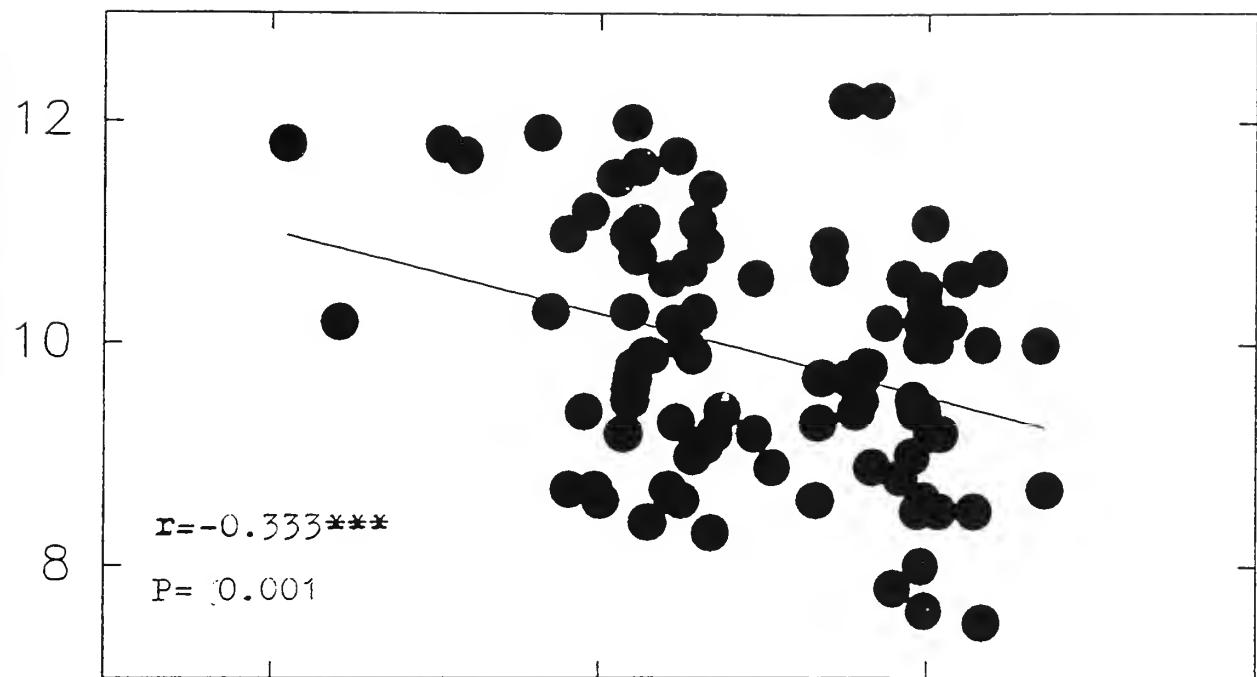
Fig. 1: Relationship between F_v/F_m, measured at seedling stage, and (a) root sugar concentration (above) and (b) total sugar content (below) in storage root at time of harvest, sex weeks later.
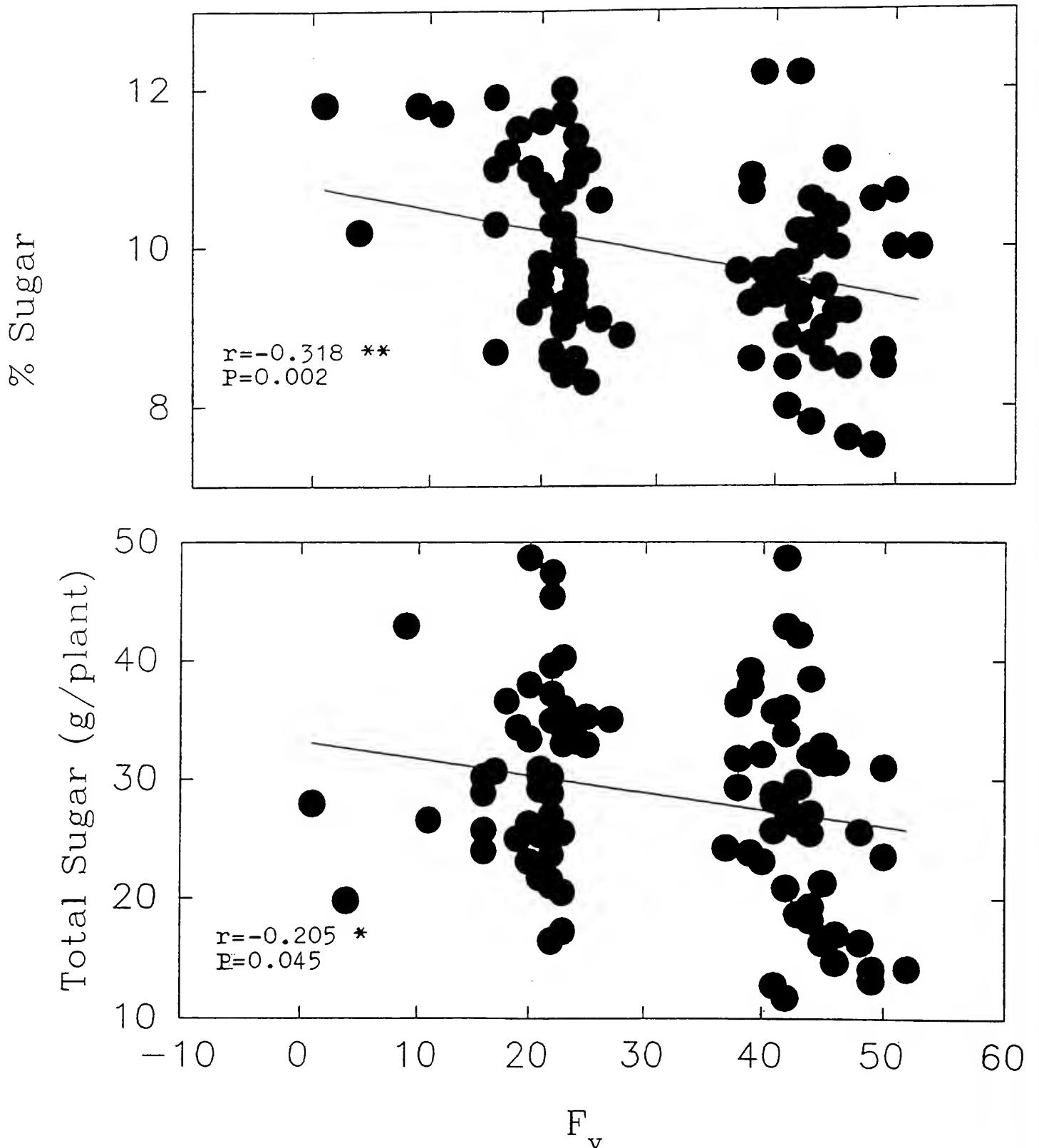
Fig. 2: Relationship between F_v, measured at seedling stage, and (a) root sugar concentration (above) and (b) total sugar content (below) in storage root at time of harvest, sex weeks later.
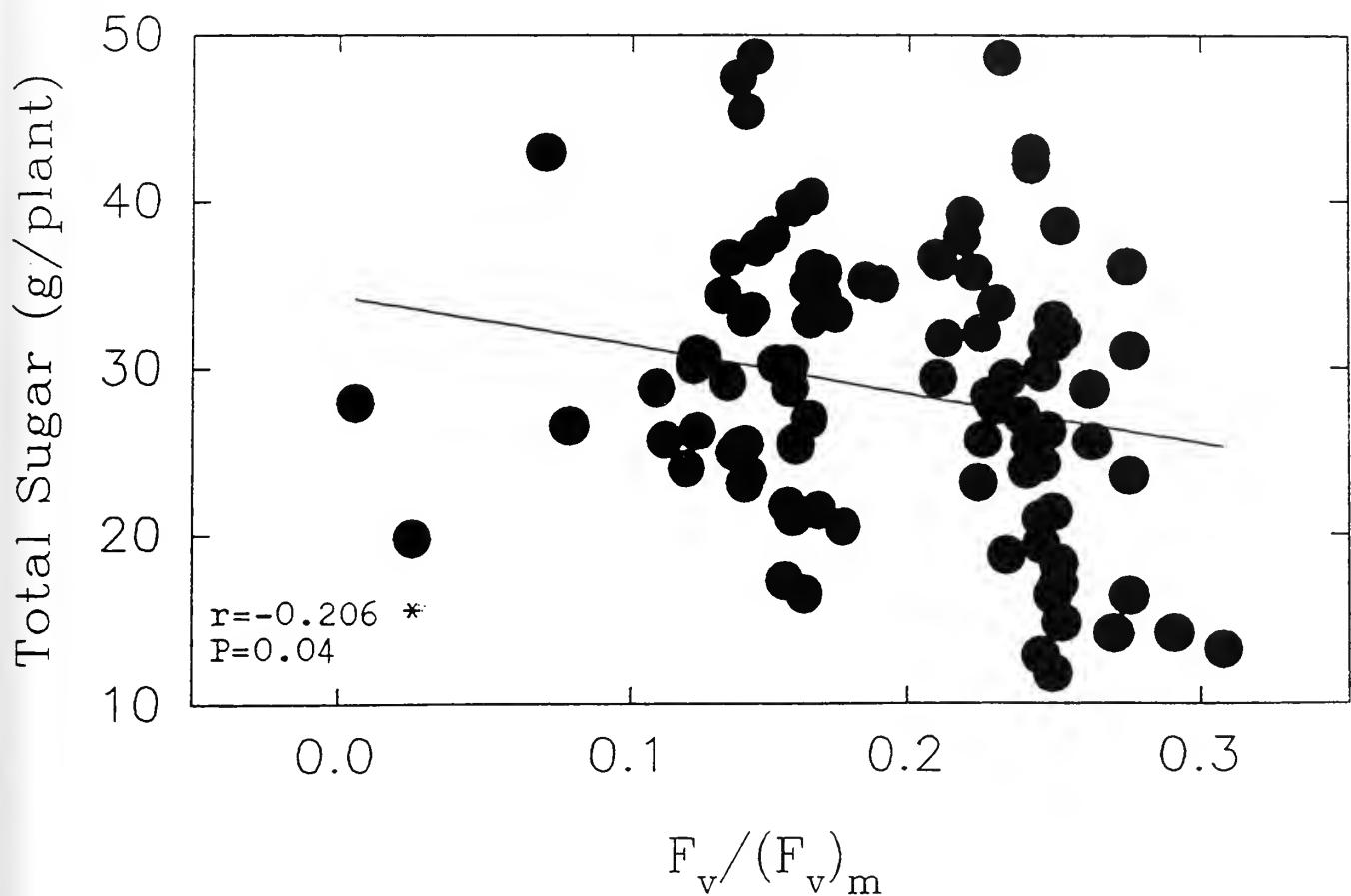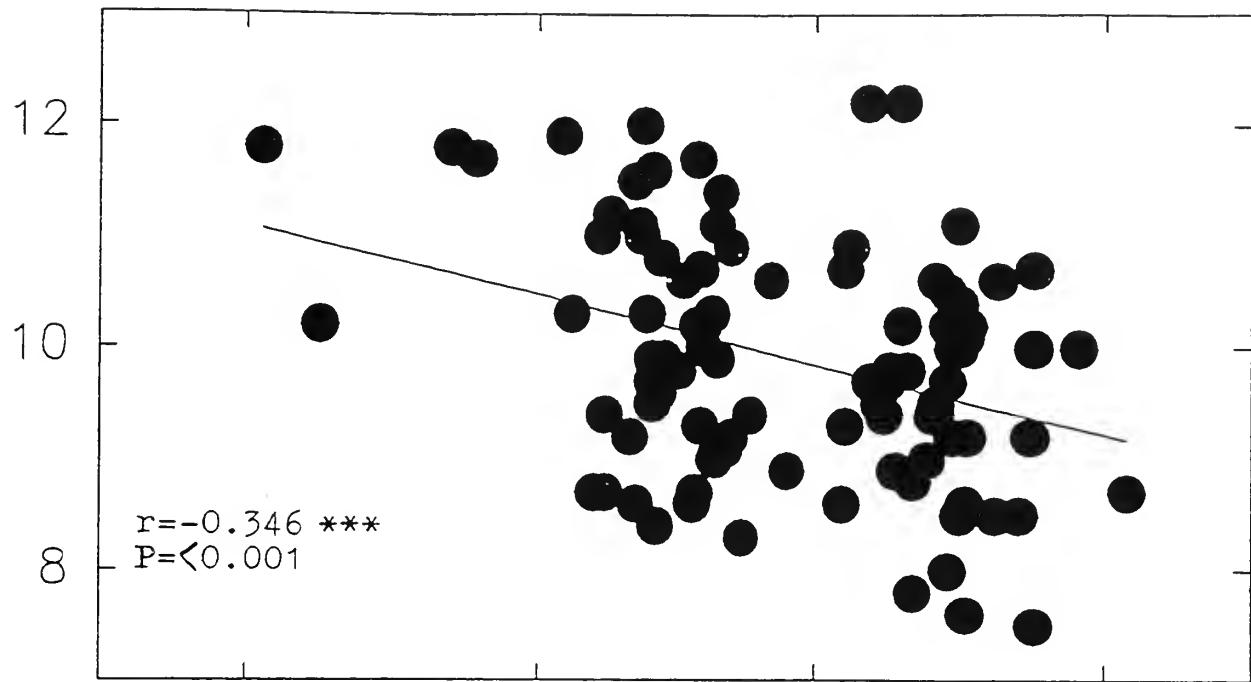
Fig. 3: Relationship between $F_v/(F_v)_{m'}$ measured at seedling stage, and (a) root sugar concentration (above) and (b) total sugar content (below) in storage root at time of harvest, sex weeks later.
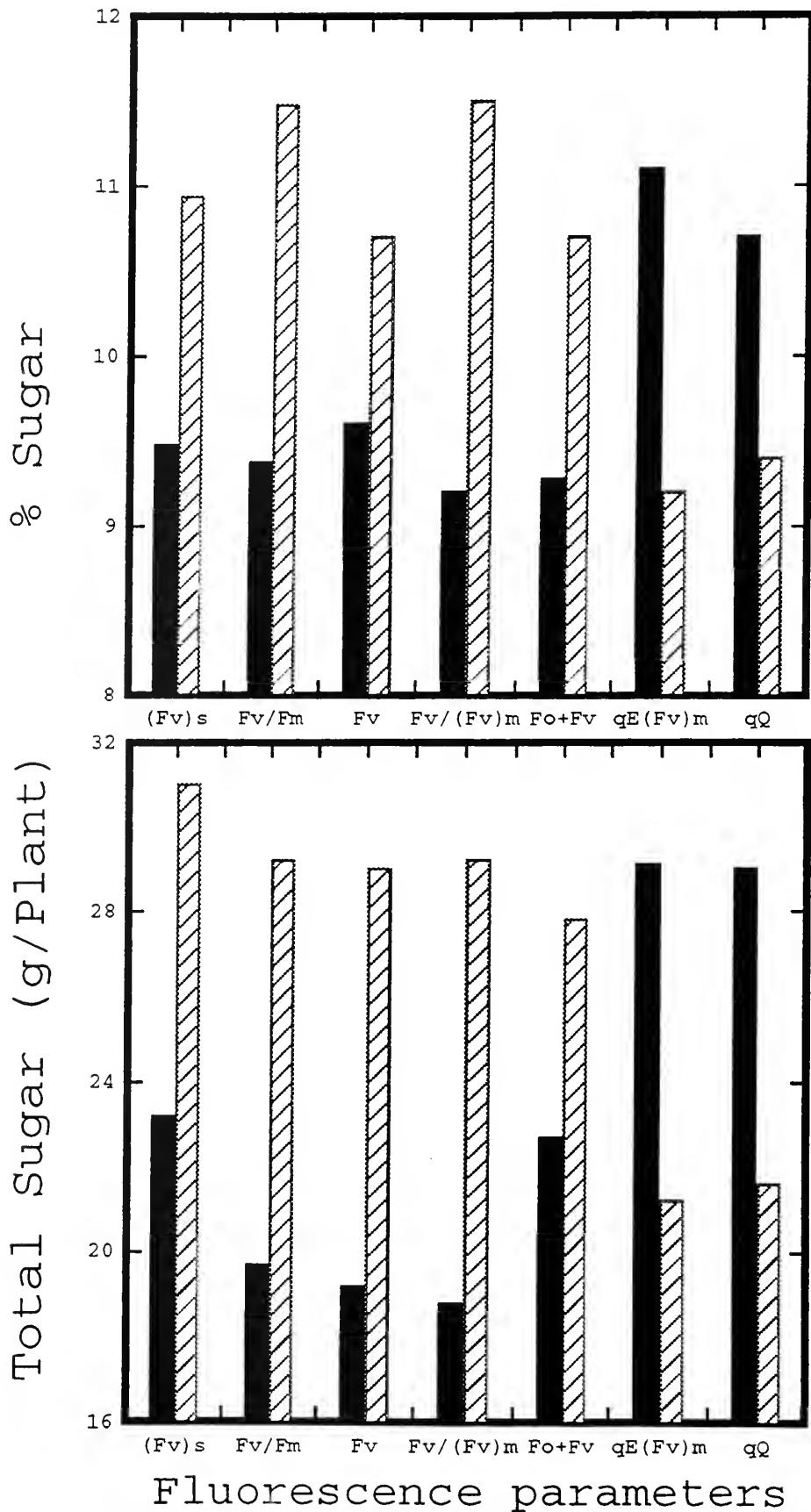
Fig. 4: Relationship between fluorescence parameters, following selections for 5 plants with high and 5 plants with low values, and (a) root sugar concentration (above) and (b) total sugar content (below) in storage root.

SUGARBEET RESEARCH

1994 Report

Section B

Plant Molecular Biology Laboratory
Agricultural Research Service
United States Department of Agriculture
Beltsville, Maryland

Dr. Lowell D. Owens, Plant Physiologist
Dr. John C. Ingersoll, Molecular Biologist
Dr. Gordon W. Snyder, Molecular Biologist

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ENGINEERED RESISTANCE TO BACTERIAL PATHOGENS

GENE TRANSFER AND CLONING RELATED TO SUGAR PARTITIONING

Huang,Y., M. Di, L. Owens and J.H. McBeath. 1994. Cecropin-mediated disease resistance in transgenic tobacco. Phytopathol. 84:1100.

Cecropin B encoded by an insect gene has been shown to confer antimicrobial activity. A chimeric gene consisting of plant promoter-secretory sequence-cecropin gene coding region, was constructed and transformed into tobacco. Untransformed plant leaves infiltrated with tobacco wildfire pathogen *Pseudomonas syringae* pv. *tabaci* at levels of 10^2, 10^3, 10^4, 10^5 and 10^6 CFU/ml showed necrosis at all inoculum levels. With cecropin-transgenic plants, however, necrosis was observed only in leaf areas infiltrated with the two higher levels, 10^5 and 10^6 CFU/ml. No necrosis was evident in areas infiltrated with bacterial dilutions 10^4 CFU/ml or less. Also, bacterial multiplication in cecropin-transgenic plants was suppressed. Expression of the cecropin gene in these plants was confirmed by western blot analysis.

Ingersoll, J.C., T.M. Heutte and L.D. Owens. 1994. Optimized transient expression in sugarbeet suspension cells for promoter analysis. Plant Physiol. Suppl. 105:137.

A group of small cysteine-rich proteins from different plant species appears to possess anti-fungal activity. These proteins have a structural likeness to thaumatin, a sweet-tasting protein from *Thaumatococcuc danielli*. Included in this group are two pathogenesis-related (PR) proteins of tobacco, osmotin (acidic) and its basic counterpart PR-S. Both osmotin and PR-S are effective in inhibiting hyphal growth in *Cercospora beticola*, the causative agent of Cercospora leaf spot disease in sugarbeet (*Beta vulgaris*). Another family of small cysteine-rich proteins involved in pathogen resistance is the leaf-specific thionins of barley. To aid in designing efficiently expressed chimeric constructs of these genes for introduction into sugarbeet plants a transient assay to assess promoter strength was developed. Constructs of the osmotin, PR-S, and a potato proteinase inhibitor 2 (*pin2*) promoter fused to the β-glucuronidase (*gus*) target gene were prepared for analysis in sugarbeet suspension cells. Experiments using 35S-*gus* chimerics were performed to optimize transient expression. The optimized protocol consisted of layering suspension cells (150 mg over a 47 mm diameter) onto a 0.45 micron nylon filter followed by a four hour incubation on SIMM media (MS salts, MS vitamins, 0.1 mM adenine sulfate, 2.5 mM MES, 3% sucrose, NAA [0.1 mg/L], BA [0.3 mg/L], pH 5.8) augmented with equal proportions of sorbitol and mannitol (250 mM total). Gold microcarrier particles (1.6 micron in dia.) coated with DNA were helium-propelled (Biorad Particle Delivery System) 11 cm at 1300 psi into the sugarbeet cells. GUS activity determined by histochemical analysis resulted in the appearance of up to 2000 blue foci per assay.

Owens, L. D. and T.M. Heutte. 1994. Degradation of cecropin B and an analogue by proteases in leaf intercellular fluids of various crops: implications for cecropin accumulation in transgenic plants. Abstr. VIIIth Inter. Congr. Plant Tiss. Cell Cult. p. 130

Tobacco transformed with a cecropin gene carrying a secretory leader sequence transcribe the gene but fail to accumulate detectable amounts of the bacteriocidal polypeptide (Nordeen, Owens et al., unpublished). Intercellular fluids (IF) were extracted from leaves of tobacco and other crops (peach, tomato, potato, soybean, sugarbeet and sunflower) and tested for their ability to degrade authentic cecropin B and a synthesized structural analogue of cecropin called MB39. The rate of degradation was greatly affected by the plant species. Tomato and potato IF completely degraded cecropin B in less than two hours, while with sugarbeet and tobacco IF about one-third remained undegraded after 2 hours. Although IF from most species displayed only exopeptidase activity, peach leaf IF appeared to cleave both peptides at a common site within the molecule. This endopeptidase activity appeared to have been rate-limiting, slowing further degradation by exopeptidase activity. These results should aid in predicting which crops may benefit from introduction of a particular cecropin gene or, alternatively, in designing a less labile cecropin molecule and its corresponding gene.

Snyder, G.W., J.C. Ingersoll and L.D. Owens. 1994. *Agrobacterium*-mediated transformation of sugar beet. Plant Physiol. Suppl. 105:114.

Sugarbeet (*Beta vulgaris* L.) is an important economic crop grown in many of the temperate regions of the world, and accounts for approximately 60% of the domestic production of sugar. Genetic improvement of sugarbeet is hampered by the complexity of the genome, making it an ideal candidate for direct gene transfer. An *Agrobacterium tumefaciens* mediated method of genetic transformation has been developed for use with leaf disc callus from Rel-1 (Tahar et al, 1991 Pat. #WO 9113159). More than 20 putative transgenic sugarbeets have been regenerated from a single experiment, with b-*glucuronidase* (GUS) activity ranging from 50-400 pMol min^{-1} mg^{-1} protein. This transformation method has been adapted for use with hypocotyl callus generated from seedlings germinated in the presence of 6-benzylaminopurine (BA) and 2,3,5-triiodobenzoic acid (TIBA). Currently, several promoter-GUS and pathogen-defense genes previously constructed in the laboratory are being introduced into sugarbeet using the patented method and the modified hypocotyl regeneration method.

Owens, L.D., J.C. Ingersoll and T.M. Heutte. 1995. Genetic engineering studies in sugarbeet: promoter analysis in transiently transformed suspension cells and degradation of antibacterial polypeptides in leaf intercellular fluids. J. Sugar Beet Res. (in press).

The rational design of gene constructs for introduction into sugarbeet necessitated development of a transient assay for assessing promoter activity in sugarbeet cells. Inducible promoters from tobacco osmotin and PR-S genes and a potato proteinase inhibitor 2 (PIN2) gene were fused to the b-glucuronidase (*uidA*) coding region and compared with a construct carrying the constitutive 35S promoter from cauliflower mosaic virus. An optimized protocol consisted of preincubating suspension cells 4 h on medium supplemented with equal proportions of sorbitol and mannitol (250 mM total) prior to bombarding with DNA-coated microparticles. At 24 h the osmotin promoter displayed activity 2.5 times that of the 35S promoter. Activities of the PR-S and PIN2 promoters were intermediate. To investigate degradation of the secreted polypeptide products of engineered genes, antibacterial cecropins were incubated with leaf intercellular fluid (ICF) from various crops. Modified cecropin MB39 had a half-life of 5.8 h in sugarbeet ICF, while that for authentic cecropin B was 4.6 h. This influence of structure on stability was observed in ICFs from other crops as well.

Snyder, G.W., J.C. Ingersoll and L.D. Owens. 1995. *Agrobacterium*-mediated and biolistic enhanced transformation of sugarbeet. J. Sugar Beet Res. (in press).

Molecular improvement of the sugarbeet is dependent on an efficient, reproducible method of direct gene transfer, therefore, our objective was to develop a simple method of genetic transformation. Seeds of Rel-1 were germinated in the dark at 27 °C for 3 weeks on medium containing 1.0 mg/l 6-benzylaminopurine (BA) and 0.5 mg/l 2,3,5-triiodobenzoic acid. The seedlings were then transferred to 4 °C for cold treatment and storage. After 2 months, the shoots were isolated, the leaves trimmed close to the stem, then incubated for 10 days in the dark at 27 °C on a high-auxin containing medium. Following the incubation, the shoots were cut through the longitudal axis, placed cut-side-up on medium containing osmotica, 0.3 mg/l BA, and 0.1 mg/l naphthalene-acetic acid. The tissue was bombarded with gold particles coated with a plasmid containing one of four pathogen-response genes. Half of the explants were then incubated in an *Agrobacterium* culture for 20 min. After a two-day cocultivation on the same medium supplemented with 100 mM acetosyringone, the explants were washed, placed on medium containing either 1.0 or 2.0 mg/l BA, 100 mg/l kanamycin and 300 mg/l cefotaxime and incubated in the light at 25 °C. After 4 weeks, green organogenic calli appeared on the explant tissue. Only the tissue inoculated with *Agrobacterium* showed regeneration, and from 10 explants 0-5 calli were produced. Generally, regeneration was better on the medium supplemented with 2.0 mg/l BA, with the controls producing only nonorganogenic green calli.

Papers Published Since Abstracted in Previous Report

Wozniak, C. A., and L. D. Owens. 1993 Use of β-Glucuronidase (GUS) as a marker for transformation in sugarbeet. J. Sugar Beet Res. 30:299-315.

Wozniak, C. A. and L. D. Owens. 1994. Native β-glucuronidase activity in sugarbeet (*Beta vulgaris* L.). Physiol. Plant. 90:763-771.

Mills, D., Hammerschlag, F.A., Nordeen, R.O., and Owens, L.D. 1994. Evidence for the breakdown of cecropin B by proteinases in the intercellular fluid of peach leaves. Plant Sci. 104:17-22.

ENGINEERED RESISTANCE TO BACTERIAL PATHOGENS
BSDF Project 800

J. C. Ingersoll and L. D. Owens

Suppression of disease by cecropin-transgenic tobacco - Transgenic (T) lines of *Nicotiana tabacum* cv. Bottom Special were produced carrying a synthetic version of cecropin B (MB39), consisting of the coding region of cecropin fused to the secretory sequence from barley a-amylase and placed under control of two different promoters. Six lines were obtained in which the partially duplicated 35S promoter from cauliflower mosaic virus was used, and five lines in which the proteinase inhibitor II (PiII) promoter from potato was used. Selfed T_1 and T_2 generations were used in testing effectiveness against challenge with the wild-fire disease bacterium *Pseudomonas syringeae* pv. *tabaci* (*Pst*).

In the first series of tests, leaves of control plants and transgenic plants carrying PiII-cecropin MB39 were infiltrated with *Pst* at levels of 10^2, 10^3, 10^4, 10^5 and 10^6 cfu/ml. Control plants showed necrosis at all inoculum levels. With cecropin-transgenic plants, however, necrosis was observed only in leaf areas infiltrated with the two higher levels, 10^5 and 10^6 cfu/ml. No necrosis was evident in areas infiltrated with bacterial dilutions 10^4 cfu/ml or less. Further, when replicate infected leaves were sampled for bacterial counts, bacterial multiplication in cecropin-transgenic plants was suppressed by about an order of magnitude at two days as compared to wild-type control plants.

In a second type of challenge, plants at the four-leaf stage were dipped in a suspension of *Pst* (10^8 cfu/ml) in the surfactant Silwet L-77 and scored for chlorosis/necrosis symptom development during the following eight days. Initial experiments indicated that symptom development was significantly lower with PiII-cecropin MB39-transgenic lines as compared to control plants. Transgenic lines carrying 35S-cecropin MB39 were generally less effective in suppressing symptom development, but more experiments are needed to confirm this preliminary finding.

Promoter analysis in sugarbeet suspensions cells - In absence of a routine and reproducible method for transforming sugarbeet, we developed an in vitro system for studying the efficiency of various promoters in sugarbeet suspension cells. Gold microparticles were coated with a mixture of DNAs, one carrying a promoter elements fused to the *gus* (β-glucuronidase [GUS]) gene coding region and a second carrying the 35S-*luc* gene encoding luciferase (LUC). The latter DNA serves as an internal standard to compensate for variability due to differences in shot pattern, microparticle coating, physiological condition of the cells, etc.

Basically the optimized system consists of layering 150 mg (FW) of suspension cells on a 47 mm nylon membrane; preculturing 4 h on medium supplemented with osmotica (0.25 mM, consisting of equal concentrations of mannitol and sorbitol); bombarding with particles propelled by 1350 psi He at a distance of 10 cm; and postculturing 24 h on the same high-osmotic medium. The cells are then removed, and extracts are analyzed for transient expression of the introduced genes. Luciferin is added to one aliquot of the extract, and LUC activity (light emisssion) is measured in a luminometer. To another aliquot methylumbelliferyl-β-glucuronide is added, and GUS activity (fluorescence of methylumbelliferin) is measured in a spectrofluorometer. LUC data are used to normalize the GUS data.

From these experiments we determined that the osmotin promoter from tobacco is much more highly expressed in sugarbeet cells than the other promoters tested, PR-S from tobacco, PiII and 35S. Expression of osmotin-*gus* was about 2.5 times higher than that for 35S-*gus*. Expression of PR-S-*gus* and PiII-*gus* were intermediate but somewhat higher than 35s-*gus*. This information was useful in designing new defense-gene constructs for use in sugarbeet.

GENE TRANSFER AND CLONING RELATED TO SUGAR PARTITIONING

G. W. Snyder and L. D. Owens

Gene transfer to sugarbeet - The patented *Agrobacterium* method for gene transfer to sugarbeet, held by Le Groupe Limagrain, was initially successful in our hands but has since proved not to be reproducible. This has necessitated further experimentation and some new approaches. Currently, a combination of micro-wounding of embryogenic callus or meristematic tissue by accelerated gold microparticles and infection with *Agrobacterium* appears promising. The tissue is derived from shoots of seedlings germinated in the dark on medium containing a cytokinin and an auxin-transport inhibitor. The shoot tissue is removed from the seedling and further cultured on a high-auxin, callus-induction medium prior to bombardment wounding and infection. Post-infection culture is in the light on selection medium designed for shoot regeneration.

Gene constructs for use in sugarbeet - A tuber-constitutive promoter from potato was subcloned for attachment to the coding region of sucrose phosphate synthase (SPS) a key gene known to exert a major influence in sugar production and export from tomato leaf. The promoter has also been attached to the cytokinin biosynthesis (*ipt*) gene which has recently been shown to mediate plant defense responses to pests. Expression of this gene in sugarbeet taproot may aid in both sugar accumulation and in pathogen defense. Attempts to introduce this gene into sugarbeet are underway.

SUGARBEET RESEARCH

1994 REPORT

Section C

Crops Research Laboratory, Agricultural Research Service
U.S. Department of Agriculture, Fort Collins, Colorado

Dr. Earl G. Ruppel, Plant Pathologist
Dr. Susan S. Martin, Plant Physiologist
Dr. Leonard W. Panella, Geneticist

Cooperation:

Colorado Agricultural Experiment Station

Contents

RHIZOCTONIA ROOT ROT RESEARCH AND DEVELOPMENT OF GENETIC RESISTANCE IN SUGARBEET
(BSDF Project 440)

1994 Field Research on Rhizoctonia Root Rot of Sugarbeet.--E. G. Ruppel and L. W. Panella.

We have been pleased to lead this cooperative research project of ARS, the BSDF, and the Colorado Agricultural Experiment Station. Our project primarily involved field studies conducted on the Colorado State University South Campus in an area reserved for Rhizoctonia root rot research. We have been informed that the university will be using this land for construction projects after the 1995 crop season. Our future research will be conducted on 35 acres of leased land near Windsor, CO.

The 1994 field experiments were planted in an area that had been in barley for 3 years and was the site of our inoculated Rhizoctonia nursery in 1990. No Rhizoctonia root rot occurred from residual fungus before inoculation of sugarbeet in 1994. Our 4-year rotation with barley apparently is sufficient for the degradation of *Rhizoctonia*-infected residues in our soils of low organic content.

Rhizoctonia evaluation experiments were planted in one-row plots 56 cm (22 in) apart and 4.3 m (14 ft) long. Experiments were planted in mid-May and thinned to a 20- to 25-cm (8- to 10-in) in-row spacing the third week of June. Dry, ground, barley-grain inoculum of *Rhizoctonia solani* (isolate R-9) was banded over the rows on July 13 at a rate of 8.4 g/4.3-m row with a tractor-mounted four-row granule applicator. Inoculum was banded in a split application, with opposite directions of travel for each application. Immediately after inoculation, we performed a cultivation designed to throw soil into sugarbeet crowns, a practice that we previously identified as being conducive to the development of root and crown rot. Our standard sprinkler irrigation regime was used to moisten and activate the inoculum. Succeeding irrigations were done by furrow. Before field inoculation, we tested inoculum for virulence on 2-mo-old sugarbeets in the greenhouse; our 1994 inoculum was highly virulent, rotting all inoculated plants.

Roots in all experiments were lifted during the week of September 11, and individually rated for rot on a disease index (DI) scale of 0 to 7, with 0 = no evidence of rot and 7 = plant dead. Percent healthy roots were those with DIs of 0 and 1, roots with no active infection. Roots with DIs 0 through 3 also were analyzed as a class; these roots were sufficiently sound and large to be recovered in a commercial harvest.

Germplasm Developments for Resistance to Sugarbeet Diseases--L. Panella, E. G. Ruppel, and R. J. Hecker (retired).

Rhizoctonia solani and *Cercospora beticola* are two fungi that may produce a severe reduction of yield in many sugarbeet production areas. Cultural control measures are not adequate by themselves, and often no chemicals are registered for control of these diseases, or chemical control is expensive or environmentally unsafe. Increased levels of genetic resistance are needed to minimize growers' losses from these diseases.

Genetic information developed previously in our research was used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our cyclic improvement program. Germplasms in various stages of improvement were evaluated for resistance in inoculated field tests. Results of these tests were the basis of decisions about specific germplasm, i.e., retain, shelve, discard, recombine, release, register, etc. Germplasms likely to be useful for variety improvement were identified and released for use by other sugarbeet breeders.

Lines developed under the breeding program of Dr. R. J. Hecker are still being evaluated in the field. Twenty lines were field-tested this summer for resistance to *R. solani, C. beticola*, and the curly top virus (Tables 1-3). Seed was increased from three lines, FC709(4X), FC710(4X), and FC712(4X), that are being converted to tetraploidy (4X) with colchicine treatment. They are lines that previously were released from the Fort Collins program as diploids (2X), with high resistance to Rhizoctonia root rot and good combining ability. A few more lines developed in Dr. Hecker's program were increased in isolation plots this summer.

Lines showing outstanding performance in 1994 field trials will be released in 1995. The tetraploids, along with a few other lines increased this summer, will be tested in the summer of 1995 and the best of these lines released.

Table 1. 1994 RHIZOCTONIA NURSERY - 6R: FORT COLLINS BREEDING MATERIALS.

Designation	Source	Pedigree	DI	% HLTHY	% HRVST	Z% HLTHY	Z% HRVST
		LSD's	.80			15.86	14.47
FC709-2[1]	921024	+ 2 cycles Rhizoc & 1 cycle sucrose	1.01	85.73	100.00	71.38	90.00
FC702-7[1]	921022	+ 7 cycles Rhizoc	1.28	69.90	100.00	57.91	90.00
FC703-5[1]	921021	+ 5 cycles Rhizoc	1.36	78.04	97.39	62.51	84.09
FC725	921008	C37/FC707-2, MM	1.36	75.68	97.42	60.98	84.11
FC727	921007	FC703/(AJ-ZZ & Aula Dei & AC 67-436), MM	1.37	69.19	100.00	59.81	90.00
FC718[1]	911032	released	1.38	75.40	97.78	60.29	86.11
FC705/1[1]		Highly Resistant Check	1.42	64.92	100.00	54.16	90.00
FC726	931010	FC703-5/Peramono, MM	1.46	66.92	97.21	56.20	83.88
FC716[1]	911028	released	1.54	64.75	98.67	54.56	87.01
FC719[1]	911037	released	1.57	55.05	98.75	47.96	87.10
FC728	921025	(MonoHy-A4 & -D2 & -309)/FC708, MM	1.65	62.84	94.18	53.20	81.18
FC729	921019	FC712/MonoHy-A4, 4 cycles Rhizoc, MM	1.65	53.04	100.00	46.52	90.00
FC715[1]	911026HO	released	1.68	60.28	98.46	50.95	86.78
FC708[1]	831085HO	released	1.69	58.89	95.33	47.32	82.19
FC721	931005HO	Syn (FC701/LSR-CTR)//C718, mm	1.79	35.73	100.00	33.38	90.00
FC703[1]		Resistant Check	1.80	59.52	93.33	50.80	82.95
	931011HO1	MonoHy-A4/FC712, CMS	1.80	50.87	94.01	45.44	79.34
	921023HO1	FC607CMS/FC708, 4 cycles Rhizoc	1.88	52.49	94.99	46.69	79.99
FC723CMS	921012HO1	EL44CMS/FC708, CMS	1.89	42.01	96.67	37.36	85.18
FC723	921012HO	EL44/FC708, mm	2.02	41.39	96.36	39.51	84.95
FC717[1]	911031	released	2.14	43.12	90.99	40.92	76.60
FC720	931007	C718//(C718/FC708), mm	2.14	36.42	91.92	37.00	77.21
FC721CMS	931005HO1	C718CMS/Syn (FC701/LSR-CTR), CMS	2.28	35.66	91.39	33.50	77.20
FC724	931008	FC702/LSR-CTR, MM	2.43	37.77	89.12	37.41	75.11
FC722	931006HO	C718/FC708, mm	2.49	14.31	92.79	19.24	78.11
FC722CMS	931006HO1	C718CMS/FC708, CMS	2.70	17.65	90.11	23.66	73.75
	921023HO	FC607/FC708, 4 cycles Rhizoc	2.84	25.78	81.59	30.50	65.13
	931011HO	FC712/MonoHy-A4, mm	3.14	26.62	73.29	24.95	62.40
	SP74464-0[1]	not for release	4.46	12.50	45.83	11.25	42.57
FC604[1]	921002HO	released	4.82	15.33	40.12	18.20	38.95
931017[1]		Susceptible Check	4.94	4.51	40.32	7.72	39.24

[1] These lines have already been released or are not being considered for release.

Table 2. 1994 CERCOSPORA NURSERY - 8A: FORT COLLINS BREEDING LINES.

Designation	Pedigree	Source	Mean Rating 1st	Mean Rating 2nd	Mean Rating 3rd	Grand All 3
		LSD's	0.590	0.659	0.559	
FC715[1]	released	911026HO	2.25	2.50	2.75	2.500
FC702-7[1]	+ 7 cycles Rhizoc	921022	2.25	2.75	3.00	2.667
FC709-2	+ 2 cycles Rhizoc & 1 cycle sucrose	921024	2.25	3.00	3.00	2.750
FC607[1]		811003HO	2.50	3.25	3.25	3.000
	Leaf Spot Resistant Check		2.75	3.25	3.25	3.083
FC720	FC607CMS/FC708, 4 cycles Rhizoc	921023HO1	2.50	3.25	3.75	3.167
	C718//(C718/FC708), mm	931007	2.50	3.50	3.50	3.167
FC708[1]	released	831085HO	2.50	3.50	3.50	3.167
FC729	FC712/A4, 4 cycles Rhizoc, MM	921019	2.75	3.25	3.50	3.167
FC721CMS	C718CMS//Syn (FC701/LSR-CTR), CMS	931005HO1	2.50	3.50	3.50	3.167
FC728	(MonoHy-A4 & -D2 & -309)/FC708, MM	921025	2.50	3.50	3.50	3.167
FC724	FC702/LSR-CTR, MM	931008	2.75	3.50	3.50	3.250
	FC607/FC708, 4 cycles Rhizoc	921023HO	2.50	3.50	3.75	3.250
FC722CMS	C718CMS/FC708, CMS	931006HO1	2.75	3.50	3.75	3.333
FC703-5[1]	+ 5 cycles Rhizoc	921021	3.00	3.75	3.25	3.333
FC727	FC703/(AJ-ZZ & Aula Dei & AC 67-436), MM	921007	2.75	3.50	3.75	3.333
FC716[1]	released	911028	2.75	3.50	3.75	3.333
FC604[1]	released	921002HO	3.00	3.50	3.50	3.333
FC719[1]	released	911037	2.75	3.50	3.75	3.333
FC717[1]	released	911031	2.50	3.75	4.00	3.417
FC726	FC703-5/Peramono, MM	931010	3.00	3.50	3.75	3.417
FC725	C37/FC707-2, MM	921008	3.00	3.75	3.75	3.500
	MonoHy-A4/FC712, CMS	931011HO1	3.00	4.00	3.75	3.583
	FC712/MonoHy-A4, mm	931011HO	3.00	3.75	4.00	3.583
FC721	Syn (FC701/LSR-CTR)//C718, mm	931005HO	2.75	3.75	4.25	3.583
FC723CMS	EL44CMS/FC708, CMS	921012HO1	3.25	3.75	4.00	3.667
FC723	EL44/FC708, mm	921012HO	3.00	4.25	4.00	3.750
FC718[1]	released	911032	3.00	4.00	4.50	3.833
FC722	C718/FC708, mm	931006HO	3.50	4.00	4.50	4.000
	Leaf Spot Susceptible Check		3.50	4.75	4.50	4.250

[1] These lines have already been released or are not being considered for release.

Table 3. 1994 CURLY TOP NURSERY - FORT COLLINS BREEDING MATERIALS

Designation	Pedigree	Source	1st Rating Mean	2nd Rating Mean	Mean of Both
		LSD's	1.06	0.94	
Beta G6040[1]	Resistant Check	94A068	4.0	5.2	4.58
FC604[1]	released	921002HO	4.5	6.2	5.33
FC720	C718//(C718/FC708), mm	931007	5.3	6.7	6.00
FC721CMS	C718CMS//Syn (FC701/LSR-CTR), CMS	931005HO1	5.5	6.8	6.17
FC723	EL44/FC708, mm	921012HO	5.3	7.2	6.25
FC722CMS	C718CMS/FC708, CMS	931006HO1	5.3	7.2	6.25
FC725	C37/FC707-2, MM	921008	5.7	7.0	6.33
	FC607CMS/FC708, 4 cycles Rhizoc	921023HO1	5.5	7.2	6.33
FC721	Syn (FC701/LSR-CTR)//C718, mm	931005HO	5.7	7.2	6.42
FC607[1]	released	811003	5.7	7.3	6.50
FC719[1]	released	911037	5.8	7.3	6.58
FC722	C718/FC708, mm	931006HO	6.0	7.2	6.58
	FC607/FC708, 4 cycles Rhizoc	921023HO	5.8	7.5	6.67
FC724	FC702/LSR-CTR, MM	931008	6.0	7.5	6.75
FC716[1]	released	911028	6.0	7.5	6.75
FC728	(MonoHy-A4 & -D2 & -309)/FC708, MM	921025	6.3	7.3	6.83
FC729	FC712/MonoHy-A4, 4 cycles Rhizoc, MM	921019	6.3	7.5	6.92
FC717[1]	released	911031	6.5	7.3	6.92
FC715[1]	released	911026HO	6.3	7.5	6.92
	MonoHy-A4/FC712, CMS	931011HO1	6.2	7.8	7.00
FC709-2	+ 2 cycles Rhizoc & 1 cycle sucrose	921024	6.3	7.8	7.08
FC723CMS	EL44CMS/FC708, CMS	921012HO1	6.3	7.8	7.08
FC726	FC703-5/Peramono, MM	931010	6.7	7.7	7.17
FC708[1]	released	831085HO	6.3	8.2	7.25
	FC712/MonoHy-A4, mm	931011HO	6.7	8.0	7.33
FC727	FC703/(AJ-ZZ & Aula Dei & AC 67-436), MM	921007	6.7	8.2	7.42
FC703-5[1]	+ 5 cycles Rhizoc	921021	6.8	8.2	7.50
FC702-7[1]	+ 7 cycles Rhizoc	921022	7.2	8.0	7.58
FC718[1]	released	911032	7.0	8.3	7.67

[1] These lines have already been released or are not being considered for release.

Base Populations to Develop Multiple Disease Resistance in Sugarbeet--L. Panella.

In a hybrid crop like sugarbeets, it is preferable that all of the parents contain some level of resistance to diseases prevalent in the area in which the hybrid is to be grown. Multiple disease resistance is a difficult goal in a crop improvement program, especially when working with an outcrossing species. In alternating generations of selection, some of the progress made in resistance to one disease is lost while selecting for resistance to other diseases.

One way of solving the problem of selecting for multiple disease resistance is the use of progeny testing. By testing the progeny of individual mother roots, plants with multiple disease resistance can be identified and used as parents of the next generation. The most efficient use of progeny testing is when the genotype of both parents is known, and the easiest way to do this is through self-pollination. In sugarbeet, there is a dominant, self-fertility gene that permits self-pollination. Used in conjunction with genetic male sterility, to insure cross pollination, a system of full-sib progeny testing can be utilized. Material from the USDA-ARS breeding program at Salinas, CA, has been crossed with some of the Fort Collins lines most resistant to *R. solani*. The Salinas material has the self-fertility allele, is segregating for genetic male sterility, and also contains a broad spectrum of resistance to diseases of importance in California as well as other sugarbeet production areas (including rhizomania, powdery mildew, virus yellows, and curly top virus).

One source population was grown in the 1994 steckling field. It is a monogerm population segregating for Rhizoctonia root rot and other disease resistances, self-fertility, and genetic male sterility. A multigerm source population segregating for Rhizoctonia root rot resistance, other disease resistances, and self-fertility will be grown in the field in 1995 (Table 4).

The monogerm population from the steckling field (F_1 population) was intracrossed ('selfed') in the greenhouse this winter. The multigerm Rhizoctonia root rot resistant population (F_1) will be planted in the steckling field in 1995. These populations, together with the materials from Dr. Hecker's program, will form the basis of a joint laboratory-field project focusing on understanding the genetics of the *R. solani*-sugarbeet interaction and producing multiple disease resistance in sugarbeets.

Table 4. Base populations currently under development.

Source	Pedigree	Description	Status
941009H2 941009H3	2890/FC708 2589/FC708	Monogerm, segregating for Rhizoctonia root rot resistance, Sf, aa, California spectrum of disease resistances	F_1 populations being increased Greenhouse over winter
941011H2	921024[FC709-2]/2915	Multigerm, segregating for Rhizoctonia root rot resistance, Sf, aa, California spectrum of disease resistances	Will be planted in the 1995 Steckling field for seed increase (i.e. F_1 population selfing).
941012H2	2915/921024[FC-709-2]	Multigerm, segregating for Rhizoctonia root rot resistance, Sf, aa, California spectrum of disease resistances	Will be planted in the 1995 Steckling field for seed increase (i.e. F_1 population selfing).
941015H2	N244/921024[FC-709-2]	Multigerm, segregating for Rhizoctonia root rot resistance, Sf, aa, SBC nematode, and rhizomania	Is on the self for now.

C9

Genetic Variation and Pathogenicity in *Rhizoctonia Solani* - L. Panella and M. K. Hjort[1]

Currently, it is possible to assay the pathogenicity to sugarbeet of an isolate of *R. solani* through a greenhouse bioassay only, which may take 12 to 16 weeks. Although there has been recent work done on the phylogenetics of this pathogen, evolutionary relationships among isolates have not been well correlated with the host specificity of the fungus. Whether the pathogenicity to sugarbeet has evolved once or more than once in this fungus could substantially influence its interaction(s) with the sugarbeet plant.

R. solani is divided into anastomosis groups (AGs) based on the ability of the hyphae to fuse and exchange genetic material, or, more recently, into intraspecific groups (ISGs) based on molecular markers, especially the internal transcribed spacer (ITS) sequences flanking the 5.8S ribosomal RNA gene (rDNA). Isolates of *R. solani* from AG-4 cause seedling damping-off in sugarbeet, and isolates from AG-2-2 cause root and crown root in mature beets.

The polymerase Chain Reaction (PCR) was used amplify the DNA of *R. solani* coding for the 5.8S ribosomal RNA gene (rDNA) as well as the two flanking ITS regions. This was done with the ITS1 and ITS4 primers (Figure 1) (Lee & Taylor, 1990). Restriction enzymes that recognize four (Alu I, Hae III, Hha I, Hpa I, Rsa I) or five (Hinf I) base-pair sites were used to create restriction fragment length polymorphisms (RFLPs) from the amplified DNA fragments. These RFLP markers were used to identify ISGs within AG-2-2.

Figure 1.

MAP SHOWING THE INTERNAL TRANSCRIBED SPACER REGIONS OF THE rDNA GENES

Isozyme markers from four enzyme systems (α- Acid phosphatase [α-ACP], Phosphoglucomutase (PGM), Glucose-6-Phospate-dehydrogenase (G6PDH), and Malate dehydrogenase (MDH)) are being used to further discriminate among isolates. The *R. solani* isolates then will be tested for their virulence in sugarbeet. The phylogenetic information will be correlated with the pathogenicity data to see if all the isolates pathogenic to sugarbeet belong to the same evolutionary group. The sugarbeet-pathogenic group(s) will be delineated with genetic markers.

Currently, DNA from 92 isolates of *R. solani* has been amplified (Table 5) and cut with the six restriction enzymes. RFLPs have been detected with these enzymes. There were also, in some cases, initial differences in the size of the amplified length of DNA, which varied from approximately 700 to 750 base pairs. The DNA was separated on agarose gels, visualized with ethidium bromide, and photographed. The enlarged photographs were used to estimate the

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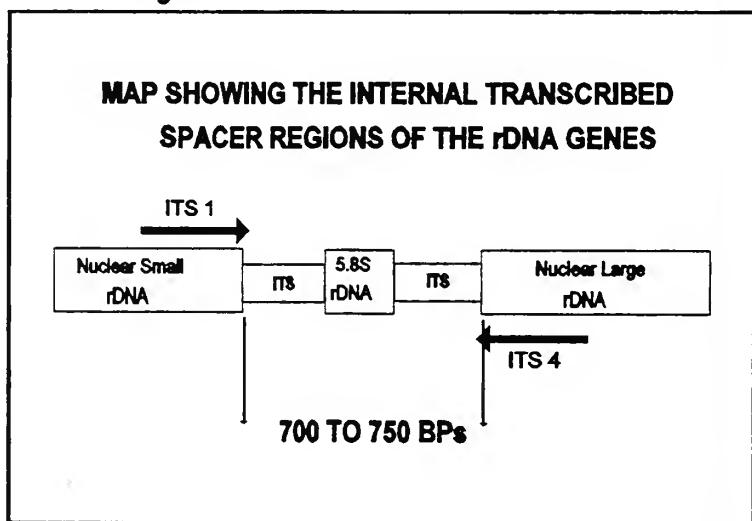
fragment sizes, by comparison with markers of known size (from a Hae III digest of ΦX174RFI). Each isolate was scored for the presence/absence of all possible RFLPs generated by each restriction enzyme (5 to 10 RFLPs each). These data were analyzed with the SIMQUAL program (NTSYS-pc from Exeter Software) which used Jaccard's coefficient to create a similarity matrix. A phylogenetic tree (Fig. 2) was generated from this information using the NJOIN program (NTSYS-pc from Exeter Software) which uses the neighbor-joining method developed by Saitou and Nei (1987). This tree does discriminate between AG-2-2 isolates and other AGs very well but does not give adequate discrimination within AG-2-2 or among the other AGs.

The RFLP data will be re-evaluated and any missing data points filled in. The isozyme study will soon be finished and those data incorporated into the RFLP data set and a new phylogenetic tree generated. If needed, more restriction enzymes will be used to discriminate among the various ISGs in the different anastomosis groups. Greenhouse tests will be used to determine the pathogenicity of the isolates of *R. solani* to sugarbeet. Test will be of seedling mortality and infection of two month old roots. These data will be correlated with the phylogenetic information to fingerprint those isolates which are pathogenic to sugarbeet.

Lee, S.B., and J.W. Taylor. 1990. Isolation of DNA from fungal mycelia and single spores. Pages 282-287, *in* M.A. Innis, D.H. Gelfand, J.J. Sninsky and T.J. White (eds.), PCR Protocols: A Guide to Methods and Applications. Harcourt Brace Jovanovich, San Diego.

Saitou, N and M. Nei. 1987. the neighbor-joining method: a new method for reconstructing phylogenetic trees. Mol. Biol. Evol. 4:406-425.

Table 5. The isolates of *Rhizoctonia solani* used in the genetic diversity study are listed with an identifying number (used in figure 2); the code of the original donor; the source, AG designation, location where collected and any remarks from the donor; the donor's name.

Rhizoctonia Isolates in Genetic Diversity Test

#	Code	Source/location/remarks	Received from
AG Testers from Akira Ogoshi			
1	CS-2	AG-1 IA	Earl Ruppel, CO
2	Shiba 2	AG-1 IB	Earl Ruppel, CO
3	BV-7	AG-1 IC	Earl Ruppel, CO
4	FC-2S	AG-2-1	Earl Ruppel, CO
5	C-116S	AG-2-2 IIIB	Earl Ruppel, CO
6	RI64S	AG-2-2 IV	Earl Ruppel, CO

7	ST11-6	AG-3	Earl Ruppel, CO
8	R101	AG-4 HG-I	Earl Ruppel, CO
9	ST 6-1	AG-5	Earl Ruppel, CO
10	IS1-1	AG-6 HG-I	Earl Ruppel, CO
11	1556	AG-7	Earl Ruppel, CO
12	TS2-4S	AG-BI (Bridging Isolate)	Earl Ruppel, CO
	AG Testers from Carol Windels (originally from Neil Anderson)		
13	S-21	AG-9 (originally from Don Carling, Palmer, AK)	Earl Ruppel, CO
	AG Tester from Steven Neate - Australia		
14	72	AG-8 (R-72 on slant); from clover roots, Con-alpyn, Australia	Earl Ruppel, CO
	Miscellaneous *Rhizoctonia* Isolates		
15	R-7	SB foliage, Willcox, AZ; by EGR (AG-4)	Earl Ruppel, CO
16	R-9	SB root, Colorado; orig. B-6 of Pierson & Gaskill (AG-2-2)	Earl Ruppel, CO
	AG Testers from Carol Windels (originally from Neil Anderson)		
17	48	AG-2-1	Earl Ruppel, CO
18	H-3-77	AG-2-2	Earl Ruppel, CO
19	P42	AG-3	Earl Ruppel, CO
	AG Testers from R. T. Sherwood		
20	S-284	AG-2-? from NC *Gypsophilla* stem (said to be "better" than W-22)	Earl Ruppel, CO
21	W-22	AG-2-2 from WI bean root (ATCC 18619)	Earl Ruppel, CO
22	W-24	AG-3 from WI potato stem (ATCC 14701)	Earl Ruppel, CO
	Miscellaneous *Rhizoctonia* Isolates		
23	NBR-1	SB root, Imperial, NE, by EGR (AG-2-2)	Earl Ruppel, CO
24	R-1	SB root, Platteville, CO; by T. Antonopoulos for Gaskill ("A")(AG-2-2)	Earl Ruppel, CO
25	R-2	SB root, Platteville, CO; by T. Antonopoulos for Gaskill (AG-2-2)	Earl Ruppel, CO
26	R-4	SB root, Brighton, CO; by EGR (AG-2-2)	Earl Ruppel, CO

27	R-5	SB crown, Ft. Morgan, CO; by EGR (AG-4)	Earl Ruppel, CO
28	R-6	SB foliage, Swink, CO; by EGR (AG-4)	Earl Ruppel, CO
29	R-8	SB root, Willcox, AZ; by EGR (AG-2-2)	Earl Ruppel, CO
30	R-14	SB root, Wellington, CO; by EGR (AG-2-2)	Earl Ruppel, CO
31	R-239	From Mike Davis (Berkeley, CA); readily formes teleomorph stage (AG-4)	Earl Ruppel, CO
32	R-1411	From Lysle Leach; highly virulent on seedlings (AG-4?)	Earl Ruppel, CO
		Isolates of AG2-2 from Charlie Rush collected in Texas	
33	R1	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
34	R3	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
35	R4	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
36	R6	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
37	R8	AG2-2 (isolated from sugarbeetroot)	Charlie Rush, TX
38	R17	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
39	R19	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
40	R27	AG2-2 (isolated from sugarbeet seedling)	Charlie Rush, TX
41	R33	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
42	R35	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
43	R36	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
44	R37	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
45	R86	AG2-2 (isolated from wheat)	Charlie Rush, TX
46	R98	AG2-2 (isolated from sugarbeet root)	Charlie Rush, TX
	Rhzc #	**Isolates of AG-2-2 from Bill Bugbee in Fargo, ND**	
47	2C1	Montana	Bill Bugbee, ND
48	5E13	Hollandale, MN	Bill Bugbee, ND
49	2A13	Montana	Bill Bugbee, ND
50	1A9	(on bran-soil) California (via Dr. Carling)	Bill Bugbee, ND
51	2C13	Montana	Bill Bugbee, ND
52	7A1	Ferry-Morse Seed Co. MN	Bill Bugbee, ND

53	5C5	MN (via Carol Windels)	Bill Bugbee, ND
54	7A5	Ferry-Morse Seed Co. MN	Bill Bugbee, ND
55	2E13	Montana	Bill Bugbee, ND
56	2C5	Montana	Bill Bugbee, ND
57	2E3	Montana	Bill Bugbee, ND
58	7A9	Ferry-Morse Seed Co. MN	Bill Bugbee, ND
Isolates of AG-2-2 from Leonard Herr at Ohio State University			
59	H502	Ohio; basidiospores of *Thanatephorus cucumeris*	Leonard Herr ,OH
60	H509	Ohio; basidiospores of *Thanatephorus cucumeris*	Leonard Herr ,OH
61	H549	Ohio; basidiospores of *Thanatephorus cucumeris*	Leonard Herr ,OH
62	H556	Ohio; basidiospores of *Thanatephorus cucumeris*	Leonard Herr ,OH
63	H581	Ohio; basidiospores of *Thanatephorus cucumeris*	Leonard Herr, OH
64	H582	Ohio; basidiospores of *Thanatephorus cucumeris*	Leonard Herr ,OH
65	H583	Ohio; basidiospores of *Thanatephorus cucumeris*	Leonard Herr ,OH
66	H585	Ohio; basidiospores of *Thanatephorus cucumeris*	Leonard Herr ,OH
67	H586	Ohio; basidiospores of *Thanatephorus cucumeris*	Leonard Herr ,OH
68	H589	Ohio; basidiospores of *Thanatephorus cucumeris*	Leonard Herr ,OH
Isolates Collected from Sugarbeets in Japan by Dr. Hirokatsu Uchino			
69	RH51	AG-4 Obihiro, Hokkaido, 1973 Damping-off	Dr. H. Uchino, Japan
70	RH52	AG-4 Obihiro, Hokkaido, 1973 Damping-off	Dr. H. Uchino, Japan
71	RH72	AG-1 Obihiro, Hokkaido, 1974 Damping-off	Dr. H. Uchino, Japan
72	RH74	AG-4 Makubetsu, Hokkaido, 1974 Damping-off	Dr. H. Uchino, Japan
73	RH105	AG-1 Makubetsu, Hokkaido, 1975 Damping-off	Dr. H. Uchino, Japan
74	RH107	AG-5 Bihoro, Hokkaido, 1975 Damping-off	Dr. H. Uchino, Japan
75	RH108	AG-1 Furano, Hokkaido, 1975 Damping-off	Dr. H. Uchino, Japan
76	RH109	AG-5 Furano, Hokkaido, 1975 Damping-off	Dr. H. Uchino, Japan
77	RH141	AG-4 Obihiro, Hokkaido, 1976 Damping-off	Dr. H. Uchino, Japan
78	RH147	AG-1 Obihiro, Hokkaido, 1976 Damping-off	Dr. H. Uchino, Japan
79	RH152	AG-4 Obihiro, Hokkaido, 1977 Damping-off	Dr. H. Uchino, Japan

80	RH26	AG-1 Obihiro, Hokkaido, 1971 Leaf blight	Dr. H. Uchino, Japan
81	RH88	AG-1 Obihiro, Hokkaido, 1974 Leaf blight	Dr. H. Uchino, Japan
82	RH89	AG-1 Makubetsu, Hokkaido, 1974 Leaf blight	Dr. H. Uchino, Japan
83	RH91	AG-4 Obihiro, Hokkaido, 1974 Leaf blight	Dr. H. Uchino, Japan
84	RH126	AG-1 Obihiro, Hokkaido, 1975 Leaf blight	Dr. H. Uchino, Japan
85	RH137	AG-1 Obihiro, Hokkaido, 1976 Leaf blight	Dr. H. Uchino, Japan
86	RH158	AG-1 Obihiro, Hokkaido, 1977 Leaf blight	Dr. H. Uchino, Japan
87	RH159	AG-1 Obihiro, Hokkaido, 1977 Leaf blight	Dr. H. Uchino, Japan
88	RH160	AG-1 Makubetsu, Hokkaido, 1977 Leaf blight	Dr. H. Uchino, Japan
89	RH193	AG-2-2 Obihiro, Hokkaido, 1990 Leaf blight	Dr. H. Uchino, Japan
90	RH198	AG-2-2 Obihiro, Hokkaido, 1991 Leaf blight	Dr. H. Uchino, Japan
91	RH65	AG-2-2 Obihiro, Hokkaido, 1973 Root rot	Dr. H. Uchino, Japan
92	RH180	AG-2-2 Bihoro, Hokkaido, 1984 Root rot	Dr. H. Uchino, Japan
93	RH184	AG-2-2 Fukagawa, Hokkaido, 1986 Root rot	Dr. H. Uchino, Japan
94	RH188	AG-2-2 Otoe, Hokkaido, 1986 Root rot	Dr. H. Uchino, Japan
95	RH189	AG-2-2 Obihiro, Hokkaido, 1989 Root rot	Dr. H. Uchino, Japan
96	RH195	AG-2-2 Kamifurano, Hokkaido, 1991 Root rot	Dr. H. Uchino, Japan
97	RH196	AG-2-2 Furano, Hokkaido, 1991 Root rot	Dr. H. Uchino, Japan

Figure 2. Rhizoctonia solani phylogenetic tree generated using the neighbor-joining method based on a similarity matrix (using Jaccard's coefficient) using the presence or absence of RFLPs. The numbers on the right refer to the # column in Table 5.
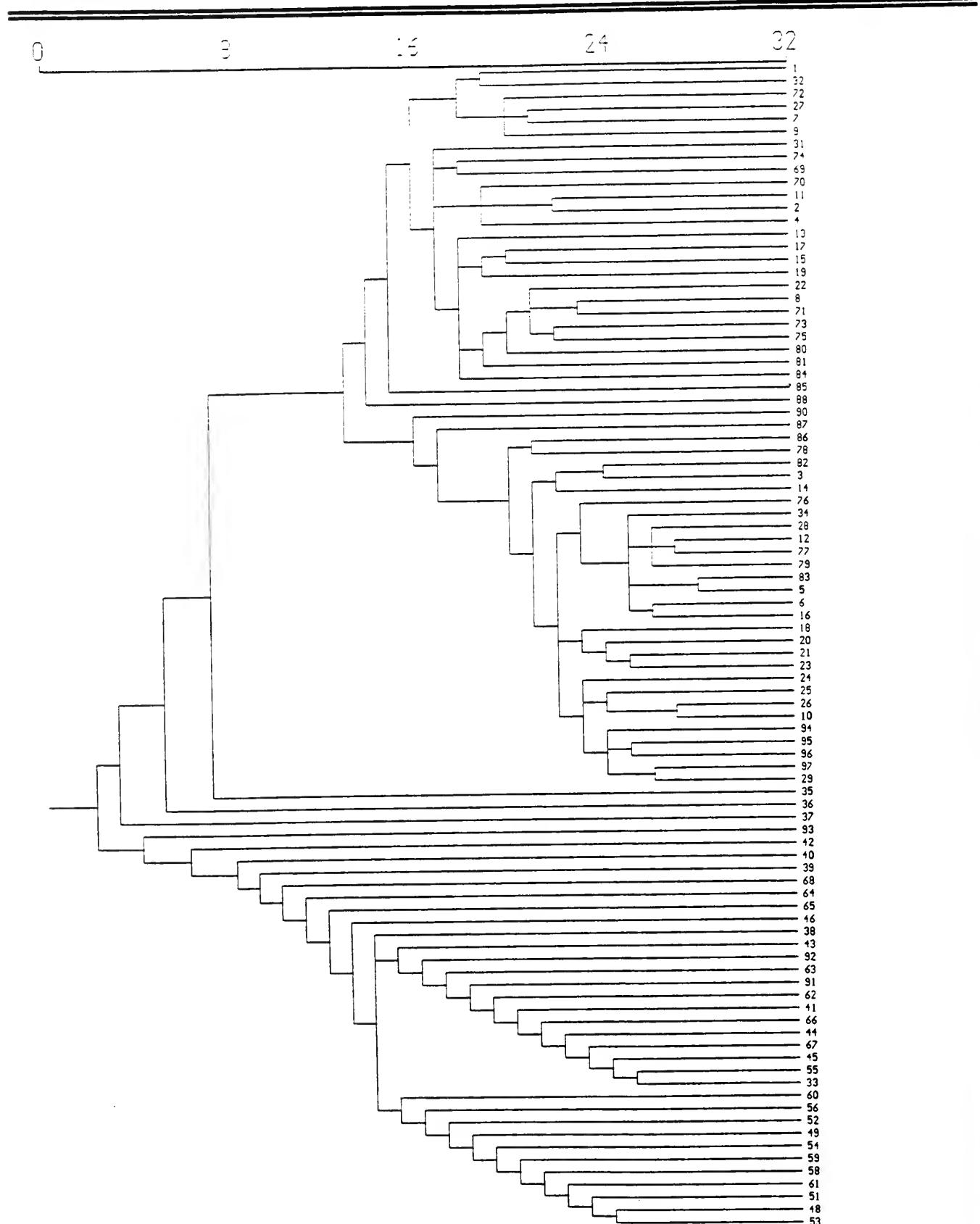
CERCOSPORA LEAF SPOT RESEARCH AND BREEDING FOR CERCOSPORA/CURLY TOP RESISTANCE
(BSDF Project 441)

Breeding for Cercospora/Curly Top Resistance - G. A. Smith[2] & L. Panella.

Resistance to *Cercospora* is especially relevant in view of the following facts: (1) If the level of resistance seen in the most Cercospora-resistant lines were present in commercial hybrids (along with good sugar and seed yield), chemical sprays would not be necessary or the availability of the chemical sprays or the allowable amounts used may be reduced; (2) The efficacy of the chemical may be diminished by pathogen resistance (which already has been reported). From these facts, we can conclude that genetic resistance to *Cercospora beticola* will become increasingly more important to the beet sugar industry.

The objectives of this program are: 1) The development of high Cercospora/Curly Top-resistant germplasm for release to the sugar industry. Lines will include monogerm CMS and O-type lines and multigerm pollinators. 2) To achieve number (1), coordination of breeding effort will continue with geneticist Dr. Lee Panella who will eventually direct the program from Ft. Collins.

A population cross among a highly Cercospora-resistant line (FC607 - ♀), a smooth root line from the USDA-ARS sugarbeet research group in East Lansing (SR87 - ♂), and commercial diploid hybrids developed by the defunct Great Western program (MonoHy A4, MonoHy T6, and MonoHy T7 - ♂'s), is being made in the greenhouse at Fort Collins. This will lead to a population of multigerm pollinators highly resistant to *Cercospora*, with good combining ability for agronomic traits. Individual mother roots will be crossed in Masonville, taking advantage of pseudo self-fertility, and the selfed seed used to progeny test for sucrose, resistance to Cercospora leaf spot, and resistance to the curly top virus.

Twenty advanced breeding lines or Cercospora-resistant germplasms were evaluated at the ARS leaf spot nursery at Ft. Collins (Table 6). These lines are part of the resistant germplasm development effort at Fargo and Fort Collins in which a new germplasm should be released every few years. The group of parents to be crossed as a population described above was crossed in the greenhouse this winter (four males - SR87, MonoHy A4, MonoHy T6, and MonoHy T7 - onto a highly Cercospora-resistant female - FC607, O-type). Hypocotyl color is being used as a marker to distinguish the hybrids.

The seed has been harvested from the female (FC607) plants. Seedlings with red hypocotyl color will be established in the 1995 steckling field at Fort Collins. These will be planted in Masonville the following year and self-pollinated, taking advantage of the pseudo self-fertility, which is conditioned by this environment. Selfed seed from individual mother roots will be progeny tested. Remnant seed from the best-performing mother roots will be inter-crossed and

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[2]Geneticist and Research Leader, USDA-ARS Northern Crop Science Lab, Fargo, ND

Table 6. 1994 CERCOSPORA NURSERY - 9A: FARGO BREEDING LINES.

Designation	Pedigree	Source	1st	2nd	3rd	All 3
		LSD's	0.37	0.71	0.44	
	FC607CMS (4X) C3	861016HO1	2.50	2.67	3.00	2.723
	FC607CMS X FC502/3, TO	871028HO3	2.50	3.00	3.00	2.833
	761036HO1CMS TC607, TO	871034HO5	2.50	3.33	3.33	3.053
	Leaf Spot Resistant Check[1]	821051H2	2.50	3.67	3.33	3.167
	FC907 (Seed increase of screened Multigerm AF92-6)	942001	3.00	3.00	3.50	3.167
	FC607 X H8277	892010H2	2.83	3.50	3.33	3.220
	FC607 (4X), TO C3	861016HO	2.83	3.50	3.67	3.333
	FC607, TO X Beta 2007 (2X)	892016H2	2.83	3.50	3.67	3.333
	FC607CMS X FC603, TO	841044HO2	2.83	3.67	3.50	3.333
FC907[1]	Oregon increase (straight)	AG92-1	2.83	3.67	3.67	3.390
	FC907, BC4	892008H2	2.83	3.67	3.83	3.443
F1011[1]	released	91N0008	2.67	4.00	3.67	3.447
	FC906, BC4	892009H2	3.00	3.67	4.00	3.557
	PI179180	91N0018	3.00	4.17	3.83	3.667
	FC607CMS, MM X L19	892001H3	3.00	4.00	4.17	3.723
F1014[1]	released	91N0011	3.17	4.00	4.33	3.833
	Beta 2007 (2X) X FC609, TO	892017H	3.17	4.00	4.50	3.890
	PI181718	91N0019	3.17	4.17	4.33	3.890
F1010[1]	released	91N0007	3.17	4.17	4.67	4.003
F1012[1]	released	91N0009	3.17	4.17	4.67	4.003
F1013[1]	released	91N0010	3.50	4.83	4.67	4.333
	Leaf Spot Susceptible Check[1]		3.67	4.67	4.67	4.337

C18

the cycle repeated to produce populations of Cercospora-resistant multigerm pollinators. Development of a resistant germplasm line generally takes seven years. A longer time may be necessary to incorporate multiple disease resistances. In an established program, a "pipeline" of lines in various stages of development and evaluation is the norm. Hence, the release of new germplasm usually occurs every two to four years.

EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO RHIZOCTONIA ROOT ROT
(BSDF Project 903)

We used randomized complete-block designs with five replications to evaluate a total of 202 lines from five companies; additionally, one company had a second test of 12 lines replicated three times. Rhizoctonia resistant FC703 and highly susceptible FC901 were included as internal controls, along with highly resistant FC705-1. Experimental design, plot size, and evaluation method are described in the section "1994 Field Research on Rhizoctonia Root Rot of Sugarbeet." The experimental design, methods, results and statistical analyses were provided to the appropriate company breeders.

Our warm, relatively dry summer provided ideal conditions for an excellent root rot nursery in 1994. Differences among entries in all tests were highly significant $P < 0.0001$. The procedure of throwing soil into the crowns provided good contrasts among entries. Mean DIs across all tests for highly resistant, resistant, and susceptible checks were 1.8, 2.2, and 5.3, respectively. Percentages of healthy roots were 55.5, 38.1, and 2.3 for these controls. Percentages of roots in disease classes 0 through 3 were 93.7, 93.2, and 30.7, respectively. The lowest and highest DIs for contributor lines across tests were 1.0 and 7.0, respectively.

EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO CERCOSPORA LEAF SPOT
(BSDF Project 904)

We used randomized complete-block designs with three replications to evaluate 287 lines from five contributors. Additionally, another contributor submitted 35 lines for a two-rep text. Internal controls included a highly susceptible synthetic and a resistant check, FC(504 X 502/2) X SP6322-0. Two-row plots were 4.3 m (14 ft) long, with 56 cm (22 in) between rows and a 20- to 25-cm (8- to 10-in) within-row spacing. We inoculated twice (June 30 and July 7). Evaluations were made on August 23, September 2, and September 8.

Although climatic conditions were favorable for the development of severe leaf spot, our 1994 epidemic was only moderately severe. On September 2, the general peak of the epidemic, means of the resistant and susceptible checks across the nursery were 3.3 and 4.8 (scale of 0-10), respectively. In most years, the difference between these means is 2+ severity grades. Means of contributor lines on September 2 ranged from 3.0 to 5.8. Means of contributor tests were tabulated, statistically analyzed, and sent to the appropriate contributor.

WORLD BETA NETWORK
(BSDF Project 442)

Lee Panella

Collections of primitive sugarbeet landraces, heritage sugarbeet varieties, other cultivated forms of beet (including chard), wild beets, and wild relatives of beets are important genetic resources for the sugarbeet breeder. Genes for disease resistance, stress resistance, and yield and quality components can be found in these plants and incorporated into commercial varieties. The World Beta Network (WBN) was founded by commercial and public researchers concerned about losses of these genetic resources and under-utilization of the collections containing these resources. It was organized in 1989 by the International Plant Genetic Resources Institute (IPGRI - formerly IBPGR) as an attempt to bring researchers, curators, and germplasm users from both developed and developing nations together to help manage and plan research to solve problems involving *Beta* genetic resources.

The last meeting at Fargo in August of 1993 was attended by 75 scientists representing 16 countries. There was a lively and highly informative exchange of scientific information. In addition to providing some of the funding for this meeting, the BSDF also covered the costs of publishing, in the Journal of Sugar Beet Research, the papers presented during the scientific portion of this meeting. Issues 30(4) containing 16 articles and 31(1&2) containing 7 articles were devoted exclusively to presentations made at the 1993 World Beta Network Meeting.

The current Beta Coordinating Committee (BCC) of the WBN consists of the permanent secretary, Dr. Lothar Frese at the Institut für Pflanzenbau in Braunschweig, Germany; Dr. Wouter Lange at the Centre for Plant Breeding and Reproduction in Wageningen, The Netherlands; Dr. H. M. Srivastava at the Indian Institute of Sugarcane Research in Lucknow, India; and Dr. Lee Panella at the USDA-ARS Crops Research Laboratory in Fort Collins, USA. There are preliminary plans to have the next WBN meeting in Izmir, Turkey, in June of 1996. This is an exciting location due to the tremendous diversity of wild beet species growing in this area and the meeting will offer a field trip to see some of these wild *Beta* populations. There will be one scientific session focused on 'biosystematics and taxonomy of the genus *Beta*' including discussion on 'concepts of wild beet germplasm conservation arising from improved biosystematic knowledge'. A second scientific session is tentatively planned to examine 'genetic diversity including diseases and pest resistance'.

There also will be regional workshops to discuss recent germplasm activities, including collection missions, to identify regional needs, and to plan cooperative activities. Recommendations arising from these regional workshops will be drafted and presented to the membership. In addition to the field trip, a short training session on species determination of the genus *Beta* will be offered, as well as a tour of the facilities of the Aegean Agricultural Research Institute which has offered to host this meeting. The BCC appreciates the continuing support of the American sugarbeet community and the BSDF.

FUNGI ISOLATED FROM DIFFERENT SUGARBEET SEEDLOTS
(BSDF Project 404)

Six seedlots were assayed for fungi occurring on and in the seed. Seedlots 1, 2, 3, and 4 were produced in Salem, OR, by the West Coast Sugarbeet Seed Company. Seedlot 3 was unprocessed seed, whereas 1, 2, and 4 were processed. Seedlot 5 was produced in a field isolation plot near Fort Collins, CO, and seedlot 6 was produced in a greenhouse isolater cage at the USDA-ARS Crops Research Lab in Fort Collins. One-hundred random seeds from each lot were distributed on four petri dishes each of five media (five seeds per dish), including water agar, acidified water agar, potato-dextrose agar (PDA), PDA with 50 μg/ml each of penicillin and streptomycin, and Czapek's solution agar. Another 100 seeds of each seedlot were surface-disinfested by immersing in 70% ethanol for 30 seconds, then immediately immersing in 1% sodium hypochlorite for 10 min, followed by two rinses in sterile distilled water. Disinfested seed were distributed on five media as described above. As fungal colonies developed on the media, transfers of hyphae were made to PDA slants for isolate identifications. When the dishes of media no longer yielded additional isolates, or when the medium was overrun with fungal growth, they were discarded. Identifications were made with the aid of a microscope. Representative isolates of several genera were retained in pure monoculture for future pathogenicity tests.

A total of 441 isolates were obtained from six seedlots (Table 1). Seedlots produced in the field in Oregon or Fort Collins, as expected, yielded the most isolates (62-92), whereas the seedlot produced in a greenhouse isolater cage yielded only 40 isolates, we of which were *Penicillium* sp. *Alternaria* spp. were most frequently isolated from all but the greenhouse seedlot, making up 62% of the total isolates.

Of the 22 identified genera, only species of *Alternaria, Cercospora, Fusarium, Phoma, Pythium,* and *Stemphylium* frequently are associated with plant diseases. The binucleate *Rhizoctonia* differs from the multinucleate *R. solani* that causes damping-off or root rot of sugarbeet. Most researchers who have tested binucleate *Rhizoctonia* isolates indicate that these isolates are nonpathogenic in sugarbeet.

Only 76 isolates (17%) were recovered from surface-disinfested sugarbeet seed, representing the genera *Alternaria, Cercospora, Chaetomella, Fusarium, Gilmaniella,* and *Phoma* (Table 2). *Alternaria, Cercospora, Fusarium,* and *Phoma* species have been reported to cause diseases in sugarbeet. Selected isolates from this group will be tested for pathogenicity in sugarbeet. Either these isolates had colonized internal seed tissues, or they had escaped the rigorous surface-disinfestation procedures.

Table 1. Number and genera of fungi isolated from six sugarbeet seed lots plated on several artificial media.

Genera	Seedlots[1]						Total
	1	2	3	4	5	6	
Alternaria spp.	52	66	66	48	40	2	274
Aspergillus sp.	4	6	0	1	0	0	11
Botryotrichum sp.	0	0	0	2	0	6	8
Cercospora sp.	0	0	0	1	0	0	1
Chaetomella sp.	0	0	0	0	0	10	10
Cladosporium sp.	0	1	0	0	0	0	1
Fusarium equiseti	1	0	0	0	1	0	2
F. solani	0	0	1	0	0	0	1
Geotrichum sp.	0	0	0	5	0	0	5
Gilmaniella sp.	2	4	2	0	0	0	8
Gliocladium sp.	2	0	0	0	0	0	2
Mucor sp.	1	2	3	0	0	0	6
Nigrospora sp.	0	1	0	0	0	0	1
Penicillium sp.	3	0	3	4	20	22	52
Phoma (?)	4	6	9	14	1	0	34
Pythium sp.	0	1	0	0	0	0	1
Rhizoctonia (binucleate)	0	1	0	0	0	0	1
Rhizopus sp.	0	1	0	0	0	0	1
Scopulariopsis sp.	1	0	0	0	0	0	1
Stemphylium sp.	9	0	0	0	0	0	9
Trichaegum sp.	1	0	0	0	0	0	1
Ulocladium sp.	1	1	0	1	0	0	3
Unknown Dematiaceae	3	1	0	0	0	0	4
Unknown Sphaeriales	0	0	0	1	1	0	2
Unknown (no spores)	1	1	0	0	0	0	4
GRAND TOTALS	**85**	**92**	**84**	**79**	**63**	**40**	**443**

[1]Seedlots 1, 2, 3, and 4 were produced commercially in Salem, OR; lots 1, 2, and 4 were processed (polished) seed, whereas lot 3 was not processed. Lot 5 was produced in an isolation field near Fort Collins, CO, and lot 6 was produced in a greenhouse isolater cage at the USDA-ARS Crops Research Lab in Fort Collins.

Table 2. Number and genera of isolates from surface-disinfested and nondisinfested sugarbeet seed plated on five artificial media.

Genera	Disinfested[1]	Nondisinfested	Total
Alternaria spp.	63	211	274
Aspergillus sp.	0	11	11
Botryotrichum sp.	0	8	8
Cercospora sp.	1	0	1
Chaetomella sp.	2	8	10
Cladosporium sp.	0	1	1
Fusarium equiseti	1	1	2
F. solani	0	1	1
Geotrichum sp.	0	5	5
Gilmaniella sp.	1	7	8
Gliocladium sp.	0	2	2
Mucor sp.	0	6	6
Nigrospora sp.	0	1	1
Penicillium sp.	0	52	52
Phoma sp.	7	27	34
Pythium sp.	0	1	1
Rhizoctonia (binucleate)	0	1	1
Rhizopus sp.	0	1	1
Scopulariopsis sp.	0	1	1
Stemphylium sp.	0	9	9
Trichaegum sp.	0	1	1
Ulocladium sp.	0	3	3
Unknown Dematiaceae	0	4	4
Unknown Sphaeriales	1	1	2
Unknown (no spores)	2	2	4
GRAND TOTAL	**76**	**367**	**443**

[1]30 sec in 70% ethanol, then 10 min in 1% sodium hypochlorite followed by two sterile distilled water rinses.

SUGARBEET RESEARCH

1994 Report

SECTION D

Northern Crop Science Laboratory, Agricultural Research Service,
   U.S. Department of Agriculture, Fargo, North Dakota

Dr. G. A. Smith, Research Leader, Geneticist
Dr. W. M. Bugbee, Plant Pathologist
Dr. L. G. Campbell, Geneticist
Dr. D. L. Doney, Geneticist
Mr. J. D. Eide, Plant Physiologist
Ms. R. L. Stolzenberg, Microbiologist
Dr. C. A. Wozniak, Molecular Biologist

Cooperation:

CONTENTS

PUBLICATIONS

Abstracts of Papers Presented, Published, or Approved for Publication

CAMPBELL, L. G. 1994. Long-term sugarbeet yield patterns of sugarbeet in Minnesota and Eastern North Dakota. *J. Sugar Beet Res.* 31: (in press).

Detailed analyses of long-term crop yield statistics not only provide a measure of changes in productivity over time but also provide insight into environmental variation patterns across a production region. Knowledge of this variation is beneficial when establishing agronomic research programs and in the interpretation of research results by producers. This study used annual county sugarbeet yields to characterize yield patterns and variability within a major sugarbeet production area, Minnesota and Eastern North Dakota. Regional sugarbeet yields have increased at an average rate of 0.2 tons/acre per year since the late 1950's and since the mid-1970's the sugarbeet acreage in this region has increased from 30% to 40% of the total US acreage. A wide range of county yields within most years indicated that environmental conditions are seldom uniform across the region. It was concluded that only a few widely spaced locations and a few years are required to adequately sample the environmental variation within the region.

CAMPBELL, L. G. and G. J. SEILER. 1994. Internal CO_2 concentration as a selection criterion for storage respiration rate in sugarbeet. *Plant Breeding* 112: 96 - 101.

Respiration is responsible for much of the sucrose loss that occurs during sugarbeet storage. Genotypes with reduced storage respiration rates would provide an efficient method for reducing sucrose losses. However, the current techniques for measuring storage respiration are not easily adapted to breeding programs. Internal CO_2 concentration has been recommended as an efficient method for measuring the respiration rate of individual sugarbeet roots in storage. This study examined the effectiveness of internal CO_2 concentration as a selection criterion for reducing respiration rate of sugarbeet during storage. Lines resulting from four cycles of divergent selection for internal CO_2 concentration were evaluated along with commercial hybrids and low internal CO_2 germplasm lines. Selection was effective in shifting internal CO_2 concentration. Relative differences in internal CO_2 concentration were consistent throughout the 3-year study. Neither the fourth-cycle selections for low nor the fourth-cycle selections for high internal CO_2 concentration were significantly different from the original population for evolved CO_2. This lack of a close relationship between internal and evolved CO_2 indicated that internal CO_2 concentration is not an effective selection criterion in a breeding program.

DONEY, D. L. 1995. Preservation of *Beta* Germplasm in the Mediterranean Region. *Diversity* 11: (In press).

Sugarbeet (*Beta vulgaris* subspecies *vulgaris* L.), a major world crop, has been cultivated for sugar extraction purposes for less than 200 years. Wild forms of beet (*Beta*), believed to have originated in the Middle East, are found as far east as India and west throughout the Mediterranean and up the North Atlantic coast. The most prevalent wild type found in the Mediterranean region is *Beta vulgaris* subspecies *maritima*. Interest in the preservation of *Beta* germplasm was stimulated in the early 1970s when genetic erosion was observed in several Mediterranean countries. Since then numerous expeditions by representatives of national and international organizations have been conducted throughout the Mediterranean region. Much of the existing wild germplasm from the Mediterranean region has been collected. Undoubtedly much has been lost; however, it is hoped that through the efforts of a united international community, the depletion of native germplasm has been halted.

DONEY, D. L. 1995. Registration of y317, y318, y322 and y387 Sugarbeet Germplasms. *Crop Science* 35: (In press).

Sugarbeet (*Beta vulgaris* L.) germplasms y317, y318, y322 and y387, developed jointly by the USDA-ARS and the Beet Sugar Development Foundation, were released in 1994. These germplasms were derived from a cross between a sugarbeet inbred and a wild beet (*B. maritima*) accession from Greece. Each is a separate family line from the fourth cycle of mass selection for root shape. Test cross analyses for these germplasms gave significant heterosis and equal to or greater root yield than commercial sugarbeet hybrids. These germplasms may be useful in elite sugarbeet breeding pools as new sources of genetic variation.

SMITH, G. A., J. D. EIDE and C. A. WOZNIAK. 1994. Isolation, identification, and characterization of *Agrobacterium* from sugarbeet galls. *J. Sugar Beet Res.* 31: (in press).

A survey of sugarbeet-associated isolates of the genus *Agrobacterium* was performed to fill a void of information about this sugarbeet pathogen, commensal and potential genetic engineering vector. Fifty-seven isolates identified as *Agrobacterium* spp. were obtained from twelve sugarbeet galls. Analyses placed these Agrobacteria in the biovar 1. Inoculation of sunflower, sugarbeet and tobacco plants with these isolates did not result in gall formation. *Agrobacterium* isolates were susceptible to the following antibiotics: carbenicillin, colistin, cefotaxime, norfloxicin and imipenem. Imipenem, a new-generation penem antibiotic, may be useful in ridding sugarbeet tissues of residual *Agrobacterium* during *in vitro* transformation experiments. Bacitracin, rifampin, streptomycin, and sulfisoxazole had no inhibitory effect on these SB-A (sugarbeet-associated *Agrobacterium*) isolates. PCR analysis indicated no *virG* was present in the SB-A. Largest galls were formed with the positive control, *A. tumefaciens* A281, on sugarbeets. Biolog cluster analysis placed

these SB-A bacteria in the *A. radiobacter* group. Given the above information, we agree with previous authors (Merlo and Nester, 1977) that *A. radiobacter* and *A. tumefaciens* should be considered as a single species.

Papers Published Since Abstracted in Previous Reports

BUGBEE, W. M. 1994. First synthetic lines aimed at cloning genes. *Sugar* 21:23.

CAMPBELL, L. C., and BUGBEE, W. M. 1993. Pre-breeding for root rot resistance. *J. Sugarbeet Res.* 30:241-251.

DONEY, D. L. 1994. Broadening the genetic base of sugarbeet. *J. Sugar Beet Res.* 30:209-219.

DONEY, D. L., and R. J. MARTINS. 1994. Selection for delayed leaf senescence in sugarbeet. *J. Sugar Beet Res.* 31:143-151.

SMITH, G. A. 1994. The theory of pre-breeding. *J. Sugar Beet Res.* 30:189-196.

WOZNIAK, C. A., and L. D. OWENS. 1994. Native β-glucuronidase activity in sugarbeet *(Beta vulgaris)*. *Physiol. Plantarum* 90:763-771.

WOZNIAK, C. A., and L. D. OWENS. 1994. Use of β-glucuronidase (GUS) as a marker for transformation in sugarbeet. *J. Sugarbeet Res.* 30:299-315.

WOZNIAK, C. A., G. A. SMITH, D. T. KAPLAN, W. J. SCHROEDER, and L. G. CAMPBELL. 1993. Mortality and aberrant development of the sugarbeet root maggot (Diptera:Otitidae) after exposure to steinernematid nematodes. *Biological Control* 3:221-225.

CERCOSPORA LEAF SPOT RESEARCH AND BIOPESTICIDE RESEARCH

G. A. Smith and J. D. Eide

BSDF Project 601

Examination and Purification of PR Proteins in Cercospora Leaf Spot Resistant Germplasm. Sugarbeets synthesize the PR (pathogenesis related) proteins in response to many stimuli, including *Cercospora* fungal attack. We are studying the molecular basis of *Cercospora* resistance, particularly the role of PR proteins chitinase and glucanase. Purification and antibody preparation can be used as a tool for evaluation of chitinase or glucanase levels by germplasm selection using ELISA. Crude extracts of LSR (leaf spot resistant) chitinase proteins were purified by differential centrifugation, ammonium sulfate fractionation and chitin affinity. Optimumization for removal of contaminating proteins was determined to be a 12% polyacrylamide, 2.67% bisacrylamide gel. Isolation of β-1,3-glucanase from LSR leaves was accomplished using affinity chromatography. Glucanase was bound to polyanhydroglucose and eluted off the column with reduced 0.5% laminarin. The proteins eluted off the column had an apparent molecular weight of 26 to 29 kD. Glucanase activity of this fraction was 332 nM glucose liberated from laminarin per second. Final purification and scale up of these PR proteins should be finished shortly. After antibody production, a simple antibody ELISA test will be used to screen seedlings for *Cercospora* resistance. This test will then be evaluated in our breeding program.

Biological Control of Sugarbeet Root Maggot. The entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* are being examined as biological control methods for sugarbeet root maggot (*Tetanops myopaeformis*) (SBRM). We have shown that the two entomopathogenic fungi *B. bassiana* and *M. anisopliae* are effective against first and third instar SBRM. They may become an important part of our IPM (integrated pest management) system for controlling the SBRM. Different formulations and application methods are being developed, including conidial application through nozzles or powdered inoculum application.

Third instar sugarbeet root maggots in petri plates were inoculated with phosphate buffer (500, 30,000 or 23 million spores per ml *M. anisopliae* or *B. bassiana*). The effect of *M. anisopliae* spores concentration on SBRM mortality is shown in Figure 1. High spore concentrations were effective in killing 94% of the third instar sugarbeet root maggots. *B. bassiana* was less effective in killing SBRM with a 30% mortality rate after 15 days. Mortality of SBRM inoculated with the entomogenous fungi was increased rapidly after two days (Figure 2). *M. anisopliae* mortality went from 2% at two days to 100% after 29 days. *B. bassiana* had a lower rate of mortality: 8% at two days up to 46% at 29 days. Spores which form on the SBRM cadavers are able to infect other viable maggots.
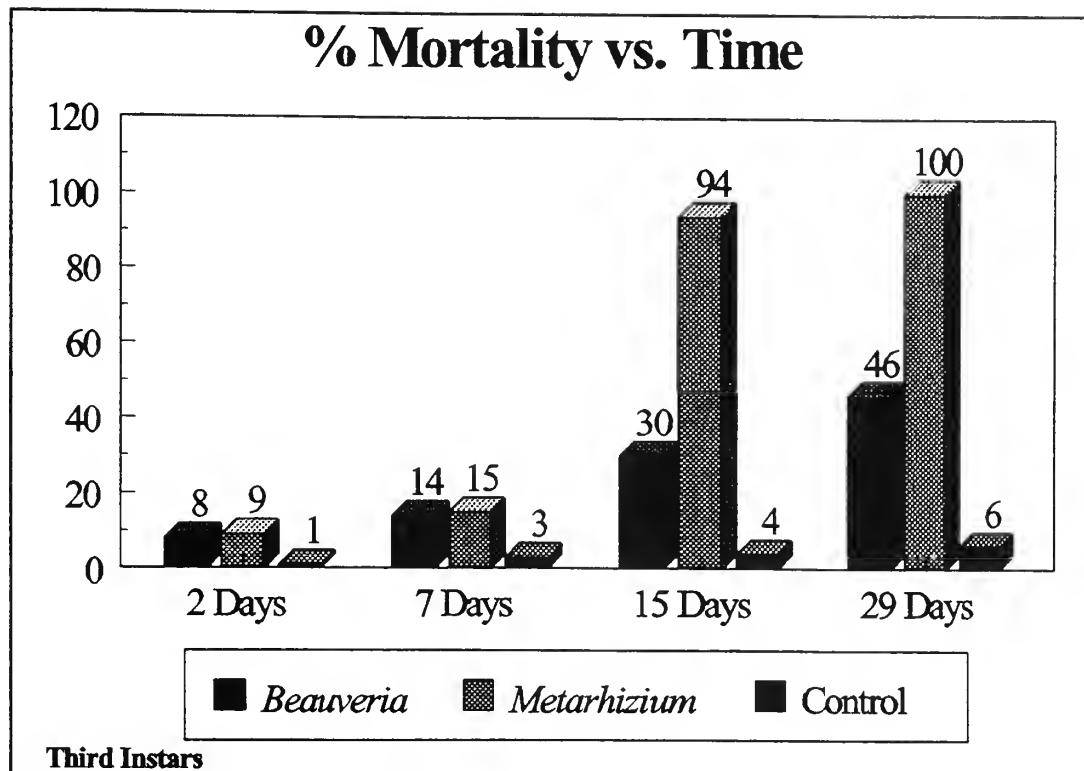
Figure 1. Mortality of third instar SBRM versus time. The inoculation rates were 23 million spores per ml.

First instar SBRM were inoculated with *M. anisopliae* and *B. bassiana*. Thirteen days after inoculation 69% of the maggots were infected with *M. anisopliae* versus 54% for *B. bassiana* (Figure 3). Inoculation of adult flies with *B. bassiana* resulted in fungal infection.

We are testing the viability of stored *M. anisopliae* and *B. bassiana* in the field and laboratory. These fungi were grown on potato dextrose soaked barley, dried and then stored at -20° and -80° C. The field material was stored in the ground Oct. 28. Viability was determined after storage by placing the fungal inoculum on PDA media. All of the laboratory stored fungi were viable after eight months (Table 1). The field stored inoculum was viable after four months. Field inoculum was exposed to soil moisture from rain and snow, and air temperature ranged from 5° to -28° C. All of the field inoculum remained viable. We will continue to monitor fungal viability and over-wintering capabilities.

Growth of *B. bassiana* was tested at different pH readings. *B. bassiana* grew on MS media from pH 5.8 to pH 10.0. This fungus should be able to survive in both alkaline and acidic soil conditions.

Field testing of *B. bassiana* and *M. anisopliae* against SBRM was carried out last summer. *B. bassiana* and *M. anisopliae* infected maggots were collected from the field plots. We are optimizing inoculation and application rates for further testing next growing season.
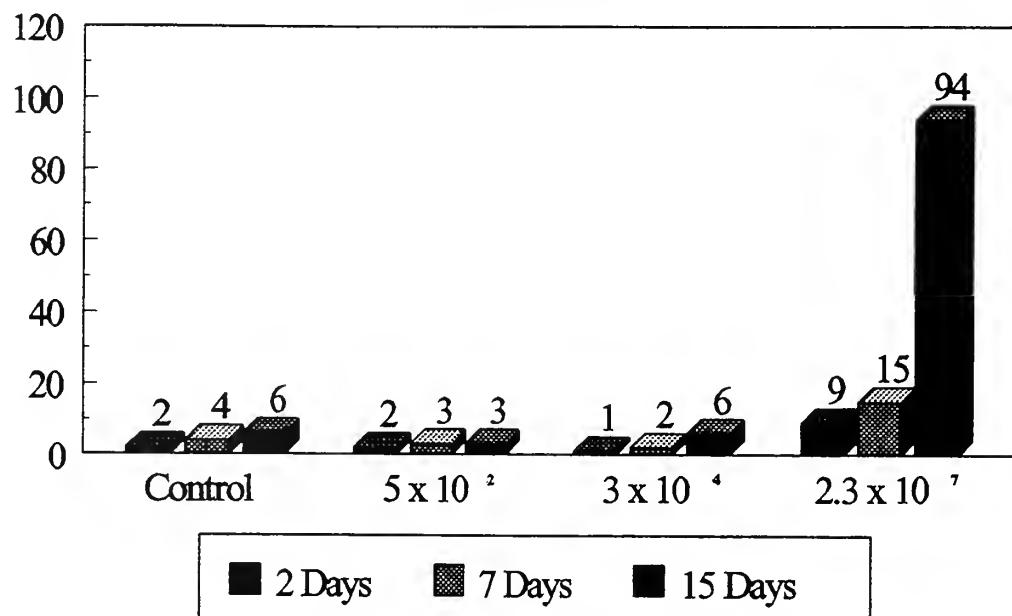
Figure 2. Effect of *M. anisopliae* condidia concentration on mortality of third instar SBRM.
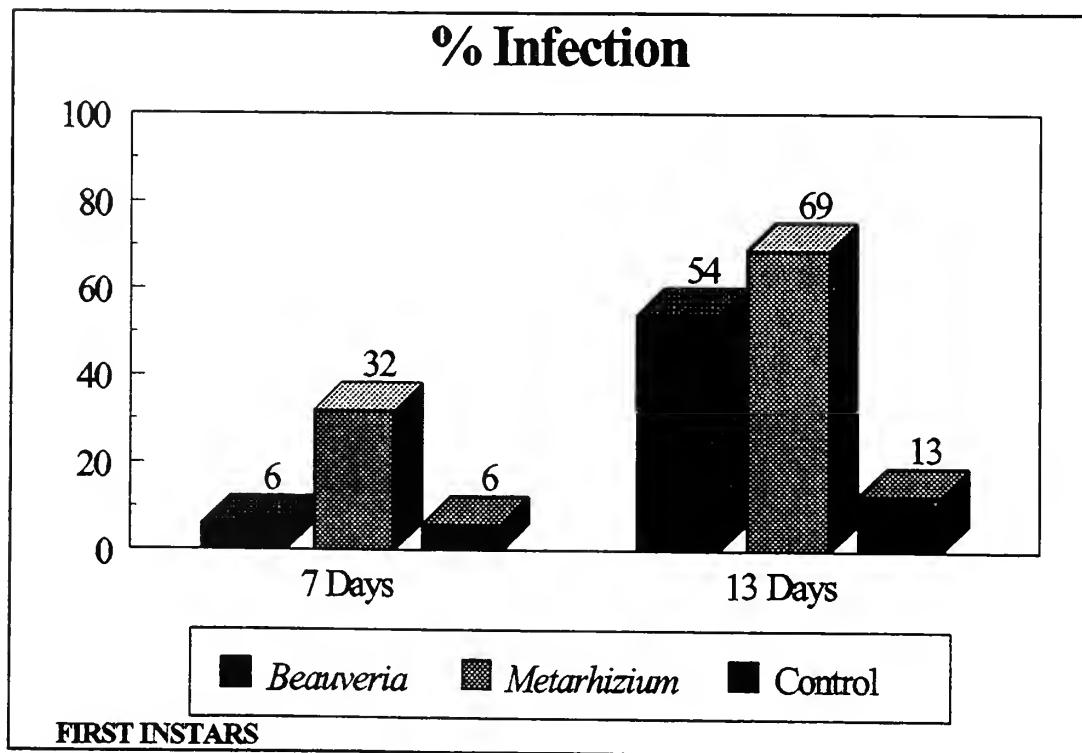
Figure 3. Percentage of first instar SBRM infected after 7 and 13 days. The inoculum density was 23 million spores per ml.

Table 1. Viability of *B. bassiana* and *M. anisopliae* stored in the laboratory and in the field over time.

Storage Conditions			Months of Storage					
			2	4	5	6	7	8
Laboratory:								
	M. anisopliae	-20° C	*	*	+	+	+	+
		-80° C	*	*	+	+	+	+
	B. bassiana	-20° C	*	*	+	+	+	+
		-80° C	*	*	+	+	+	+
Field:								
	M. anisopliae		+	+	*	*	*	*
	B. bassiana		+	+	*	*	*	*

+ = Viability on PDA.   * = Not tested.

Field tests for stored inoculum were begun in September 1994 and will continue through June 1995.

CERCOSPORA BETICOLA TOLERANT TO TRIPHENYL TIN HYDROXIDE

W. M. Bugbee

BDSF Project 610

Triphenyl tin fungicides (hydroxide, chloride or acetate) are very effective against *Cercospora beticola* for control of leaf spot on sugar beet. Triphenyl tin hydroxide (TPTH) was found to be superior to copper and carbamate fungicides in toxicity, leaf retention and duration and has been used extensively in the Northern Plains and Texas sugar beet regions of the United States, where Cercospora leaf spot is a problem. Usage increased dramatically after the rapid development of strains that became resistant to the benzimidazole fungicides in the early 1980's, and TPTH is now the primary fungicide for Cercospora leaf spot control on sugar beet.

Tolerance of strains of *C. beticola* to triphenyl tin have been reported from Greece, Yugoslavia and Italy. Since 1986, field isolates of *C. beticola* have been tested in our laboratory for tolerance to TPTH. In 1994, there were fields from west-central and southern Minnesota where control of Cercospora leaf spot was not as complete as had been experienced in the past. When conidia of *C. beticola* were transferred to media containing TPTH, the amount of growth indicated that the fungus had acquired tolerance to the fungicide. Evidence of tolerant strains is reported here.

Results and Discussion. Isolates of *C. beticola* with tolerance to 5 ppm TPTH were found in leaf samples from two of five fields in the Minn-Dak district of Minnesota (Table 1). These fields had received the maximum or near maximum amount of TPTH allowed during the growing season. The two fields that had tolerant isolates also had leaf spot severe enough to require additional treatment. The leaf spot severity was at least 3%, which is severe enough to cause economic damage. Isolates from these fields were susceptible to thiophanate methyl but tolerant to 5 ppm mancozeb. Recommended dosages for mancozeb are about 7.5 times higher than that required for TPTH, which accounts for the mancozeb tolerance.

A field in southern Minnesota developed an unacceptable level of leafspot in September after receiving the maximum legal dose of TPTH. Spores were removed from spots on five leaves and transferred to 1 ppm or 5 ppm TPTH or thiophanate methyl (TM). TM is the active ingredient in Topsin-M. The results in Table 2 show that many colonies grew on 1 ppm TPTH with 70 - 79% inhibition of growth, with no growth at 5 ppm. With TM, fewer colonies grew but those that did grow were inhibited less than those grown on TPTH.

Table 1. Growth of isolates of *Cercospora beticola* from west-central Minnesota (Minn-Dak) on 5 ppm triphenyl tin hydroxide (TPTH), thiophanate methyl (TM) or mancozeb expressed as per cent inhibition of linear growth compared to the unamended growth medium.

Field	Percent growth inhibition and the number of colonies that developed from conidia transferred from 25 leaf spots per field					
	TPTH		Topsin-M		Mancozeb	
	%	Colonies	%	Colonies	%	Colonies
A	24	21	100	0	5	20
B	100	0	100	0	10	25
C	100	0	100	0	21	20
D	25	23	100	0	6	21
E	100	0	100	0	4	20

Table 2. The effect of triphenyl tin hydroxide (TPTH) and thiophanate methyl (TM) on isolates from a southern Minnesota sugar beet field expressed as inhibition of linear growth when compared to the unamended medium.

Leaf	Fungicide	Inhibition of linear growth at			
		1 ppm		5 ppm	
		%		%	
A	TPTH	70	10/11[a]	100	0/15
	TM	0	2/15	5	4/15
B	TPTH	72	27/30	100	0/15
	TM	100	0/15	10	5/15
C	TPTH	72	7/15	100	0/15
	TM	16	7/15	8	1/7
D	TPTH	76	19/19	100	0/15
	TM	6	5/15	100	0/4
E	TPTH	79	15/15	100	0/15
	TM	0	13/15	100	0/15

[a] = Number of transfers that grew per number of leaf spots that were transferred, i.e. 10/11 = conidia from 10 leaf spots formed colonies out of 11 leaf spots that were transferred.

The response of 57 randomly selected isolates to TPTH are listed in Table 3. At 0.125 ppm TPTH, over half of the 57 isolates were inhibited only 11%-30%. At higher concentrations, there was a shift toward increased inhibition. At 0.5 and 1 ppm TPTH, there were 3 and 2 isolates respectively that were inhibited 51%-70%. These results show that about 50% of this population was tolerant to the lowest concentration of TPTH and that 3.5% were tolerant to the highest concentration.

Table 3. The response of 57 randomly selected isolates of *Cercospora beticola* to four concentrations of triphenyl tin hydroxide (TPTH).

Percent Inhibition[a]	Number of Colonies TPTH, ppm			
	0.125	0.250	0.500	1.000
0 - 10	0	0	0	0
11 - 20	12	0	0	0
21 - 30	16	2	0	0
31 - 40	5	1	0	0
41 - 50	2	0	0	0
51 - 60	7	5	2	1
61 - 70	3	18	1	1
71 - 80	1	16	14	9
81 - 90	11	14	28	24
91 - 100	0	1	12	22

[a] Inhibition was calculated as (control - treated)/control based on colony diameter after 6 days at 25 C.

Three triphenyl tin-tolerant isolates were grown on TPTH, mancozeb and a mixture of the two. Growth inhibition increased as the concentration of the fungicides increased, with mancozeb being more effective than TPTH (Table 4). Mancozeb was used at 7.5 times the concentration of TPTH because there is a commercial product available with this same ratio of mancozeb to tin. There was an additive effect when the two fungicides were mixed but only at the two lowest concentrations. The data indicates that a tank mix would be beneficial if a low dose was applied to leaves, for whatever reason. Also, the data indicates that mancozeb is effective against the tin-tolerant strains.

Table 4. The effect of triphenyl tin hydroxide (TPTH) and mancozeb on linear growth of TPTH-tolerant strains of *Cercospora beticola*.

ppm		Inhibition of linear growth, %		
TPTH	Mancozeb	TPTH	Mancozeb	Both
0.125	0.937	12j[a]	64f	76e
0.250	1.875	17i	79d	86c
0.5	3.750	42h	88c	87c
1.000	7.500	57g	97a	94b

[a] Data followed by the same letter are statistically not significant based on Duncan's multiple range test at the 95% level of probability.

We are probably in the early stage of a buildup of strains tolerant to TPTH, based on laboratory results and the number of fields with an unsatisfactory level of leaf spot control. A survey for 1995 is proposed for our entire sugarbeet growing region to estimate the prevalence and distribution of tolerant strains. This baseline of data may provide some guidance in the use of proper management practices.

Using a Pectin Lyase Inhibitor to Enhance Resistance to *Rhizoctonia Solani*. It was reported here previously of the purification and partial characterization of pectin lyase, an important disease-related enzyme from *Rhizoctonia solani*. Also, we reported the partial purification and characterization of a proteinaceous inhibitor of pectin lyase called a pectin lyase inhibitor protein (PNLIP) that was produced by the sugarbeet. Our working hypothesis is that the PNLIP gene can be manipulated to over-produce PNLIP and thereby increase resistance to root rot by deactivating the pectin lyase that is produced by *R. solani*. Antibodies to PNLIP have been used to probe for the PNLIP-encoding sugarbeet gene.

mRNA from sugarbeet root tissue was isolated and used to generate a library of cDNA. The cDNA was ligated to plasmids. Several different strains of *Escherichia coli* were transformed with the ligated plasmids. Monoclonal and polyclonal antibodies to PNLIP were used to probe transformed bacterial lysates bound to nitrocellulose membranes. Western blots also were done on electrophoretically-separated lysates. The polyclonal antibodies proved to be nonspecific when used to probe lysates that were directly bound to nitrocellulose. The monoclonal was more specific and positive bacterial clones were indicated but positive reactions never occurred with separated proteins on Western blots. Lysates from positive clones also were assayed directly for PNLIP activity using pectin lyase as the substrate in a standardized procedure but there was no inhibitory activity. It is possible that *E. coli* could not express the PNLIP protein under the conditions that existed in this protocol or, if PNLIP was being expressed, the monoclonal would not function under these assay conditions.

The first nine amino acids from the amino terminal of PNLIP have been determined. This information was used to purchase two custom synthesized oligonucleotides from National Biosciences, Inc. These oligos can be used in future efforts to engineer the PNLIP gene in sugarbeet.

BROADENING THE GENETIC BASE OF SUGARBEET (PRE-BREEDING)

D. L. Doney

Even though significant breeding progress is still being made in sugarbeet, continued improvement into the next century is dependent on the infusion of new and/or additional genetic variation into sugarbeet breeding pools. The most likely source of new genetic variation is from untapped wild germplasm. Survival through generations of severe stress has accumulated growth genes unlike those in our present sugarbeet breeding pools.

The major objective of this research is to develop near-sugarbeet type populations containing new genetic variation for use in elite sugarbeet breeding pools. Secondary objectives include the development of effective selection criteria.

Releases. Four germplasms (y317, y318, y322 and y387) resulting from a cross between a wild source (*Beta maritima*) and a cms sugarbeet inbred were released to the industry. These lines are the result of four selection cycles for sugarbeet root shape. Hybrids with these lines gave root yields equal to current sugarbeet hybrids. These germplasms contain many genes from their wild parents and should add new genes to the current sugarbeet breeding pool. Although moving genes for disease resistance from wild sources into domestic sources in not new, this is one of the first demonstrations of the transfer of genetic variation for growth from wild relatives.

Since the original cross was between a cytoplasmic male sterile sugarbeet inbred, male sterile cytoplasm is present in all four populations. Breeders should be able to isolate cms plants from these populations. Population y317 is self-fertile, whereas the other three are segregating 50% self-fertile plants. All are segregating for red/green Hypocotyl (y387 11% red and the rest 50% red).

New Populations. Seven new populations derived from crosses between a sugarbeet line segregating for genetic male sterility and regional mixtures of *Beta maritima* or other subspecies of *B. vulgaris* have advanced through two cycles of random intercrossing and two cycles of selection for early emergence and early leaf initiation. The two cycles of random intercrossing were to effect recombination between the two germplasms (wild and sugarbeet types). The two selection cycles eliminated germination inhibitors and increase the speed of early growth. Both selection efforts have been effective; however, it appears that, at this stage, only one cycle of selection for early germination and early leaf initiation is necessary. These populations will be grown in space-planted field trials for root shape selection.

New Crosses. Crosses between 40 North Atlantic *Beta maritima* accessions and a self incompatible sugarbeet line were made this past year. Several plants (up to 10) from each accession were individually crossed to the sugarbeet line. An equal number of plants (10) for each F_1 cross of each accession will be used in an intercross to produce the F_2 populations. Earlier observations suggested that considerable genetic segregation was taking place within each accession. This method was developed to insure that the genetic variation existing within each accession was represented in the original cross and subsequent random mating intercrosses.

Selection: First Leaf Initiation. Studies over the past three years pertaining to the *first leaf initiation* selection criteria have shown that: 1) the leaf initiation of the first leaf can be altered genetically, 2) changes in the initiation time of the first leaf changes the initiation of subsequent leaves, and 3) these changes appear to be related to overall growth rate. Preliminary tests conducted in 1993 also suggested that changes in leaf initiation affect field growth and yield. This past year studies were conducted to evaluate the genetics of this characteristic and its relationship to growth and yield.

Tests in Wild Germplasm (Populations of wild x sugarbeet crosses). The seven new *Beta maritima* x *Beta vulgaris* populations mentioned above were evaluated for the effects of early leaf initiation selection in these populations. The populations resulting from two cycles of random intercross (F_3) and the subsequent leaf initiation populations (cycle 1 and cycle 2, respectively) were tested for population changes in leaf initiation. These tests were conducted under growth chamber conditions identical to those previously used for selection purposes. In addition to leaf initiation measurements, leaf length measurements were taken (two 24-hour periods) to determine the growth rate of emerging leaves.

The hours between emergence and the time the first leaf reached 1 cm was generally less for each selection cycle (Table 1). In addition, the leaf length at 135 hours post-emergence was larger for each selection cycle, as expected. If selection for early leaf initiation was in reality a selection for faster growth, it would be reflected in the slope, which is a measure of growth rate for leaf length. The slope generally followed the same trend, i.e. the slope increased with each selection cycle. Two populations (Ireland and *patula*) did not follow this trend and gave mixed results. The overall mean showed a decrease in number of hours for the first leaf to reach 1 cm in length, and the leaf length expanded more rapidly with each selection cycle. These results confirm that this selection technique is effective in wild as well as cultivated *Beta* germplasm.

Table 1. Leaf length, slope and first leaf initiation of the F_3, cycle 1 and cycle 2 generations for seven *Beta maritima* x *Beta vulgaris* crosses.

Source of Wild Germplasm	Cycle	LF Length 135 Hrs Post-Em	Slope*	Leaf Initiation Hours Post-Em
Denmark	F_3	24.2 a	0.42 a	106.6 a
	Cycle 1	28.9 b	0.45 a	104.8 b
	Cycle 2	35.0 c	0.55 b	97.3 c
Belgium	F_3	29.7 a	0.27 a	104.0 a
	Cycle 1	29.7 a	0.47 b	104.8 a
	Cycle 2	36.1 b	0.56 c	95.3 b
Ireland	F_3	25.5 a	0.49 a	105.0 b
	Cycle 1	28.0 a	0.53 a	108.0 a
	Cycle 2	31.4 b	0.49 a	102.6 c
Macrocarpa	F_3	28.9 a	0.46 a	105.1 a
	Cycle 1	31.6 b	0.71 b	105.6 a
	Cycle 2	33.5 b	0.63 b	102.6 b
Patula	F_3	32.2 a	0.28 a	100.6 ab
	Cycle 1	32.1 a	0.63 b	99.0 a
	Cycle 2	33.6 a	0.58 b	102.5 b
TII	F_3	29.2 a	0.50 a	106.0 a
	Cycle 1	30.1 a	0.66 b	103.6 b
	Cycle 2	30.3 a	0.54 a	101.9 c
Atriplicifolia	F_3	25.8 a	0.47 a	109.7 a
	Cycle 1	30.1 b	0.54 b	106.4 b
	Cycle 2	28.1 b	0.61 c	105.3 b
Mean	F_3	28.3 a	0.41 a	105.2 a
	Cycle 1	30.1 b	0.57 b	104.6 a
	Cycle 2	32.6 c	0.57 b	101.0 b

* Slope = growth rate of leaf length

Genetics of Early Leaf Initiation. Last year two separate males x females genetic crosses suggested that both additive and non-additive genetic variation influenced the leaf initiation character. Additional tests were conducted this past year to estimate the genetic gain attributed to the two types

of genetic variation. These tests consisted of comparisons between selections made from the same parent using both mass and recurrent selection methods (Table 2).

The first comparison in Table 2 is between divergent selection populations based on mass selection. The significant difference between the divergent selections suggests that additive genes were responsible for the differences. The second comparison, between hybrids of the parent and the early mass selection line, gave a significantly shorter time for leaf initiation in the early mass selection hybrid, due to additive type genes. The additional effect of non-additive genes is demonstrated in the third comparison (early recurrent vs early mass selection hybrids). Non-additive genes are also responsible for the differences between divergent recurrent selection hybrids (fourth comparison). The last comparison combines the effects of both additive and non-additive genes. These comparisons demonstrate that the leaf initiation character is influenced by both additive and non-additive genes.

Table 2. Estimates of additive and non-additive genetic variation between selected populations.

Entry	Type of Selection	Expected Genetic Variation	Leaf Initiation Hours Post-EM for 1st Leaf=1cm
i23INE	Early - Mass Selection	Additive	98.6 **
z5	Late - Mass Selection	Additive	101.6
L53cm x i23INE	Early - Mass Selection Hybrid	Additive	96.8 **
L53cm x i32	Parent Hybrid		100.1
L53cm x z6	Early - Recurrent Selection	Non-Additive	94.9 **
L53cms x i32INE	Early - Mass Selection	Additive	96.8
L53cms x z6	Early - Recurrent Selection		94.9 **
L53cms x z5	Late - Recurrent Selection	Non-Additive	99.4
L53cms x z6	Early - Recurrent Selection	Non-Additive	94.9 **
L53cms x i32	Parent Hybrid		100.1

**Significant difference at $p = 0.01$.

Table 3. Expected rank in root yield, root sucrose percentage and sugar yield of selected lines and their respective leaf initiation ranking.

Cultivar	Expected Rank for			Leaf Initiation Rank
	Root Yield	Sucrose %	Sugar Yield	
ULTRAMONO	2	2	1	2 b
L53 x A4	3	3	2	1 a
BLANCA	1	5	3	3 c
L19	4	1	4	4 d
L53	5	4	5	5 d

Growth Effect. Several lines that differ significantly in their known root yielding characteristics were tested for yielding relationships with leaf initiation (Table 3). The leaf initiation rank best fit the rank for sugar yield, with the exception that hybrid L53 x A4 which ranked first for leaf initiation compared to its expected rank of second for sugar yield. This test tends to confirm earlier suggestions that early leaf initiation selection applies selection pressure on growth, since sugar yield is highly correlated with root dry weight yield.

Early Leaf Initiation and Field Yield. Results of field tests conducted in 1993, despite severe flooding, implied that selection for leaf initiation significantly affected root yield. Replicated field trials in 1994 were designed to further evaluate the influence of leaf initiation selection on root yield. Unfortunately, field plots were again flooded, resulting in abandonment of most of the field trials. Two trials that were less affected were retained until harvest; however, plant stands were significantly reduced. Adjustment of root yields based on plant stand increased the precision; however, estimates of the coefficient of variation (CV) were still over 20%. No differences in root yield were observed between leaf initiation selections (Tables 4 and 5). More reliable data are necessary to determine the true influence of leaf initiation selection on root yield.

Table 4. Root yield, sucrose percentage and sugar yield of leaf initiation (IN) selections using mass and recurrent selection (RS) methods.

Entry	Type of Selection	Root Yield	Sucrose	Sugar Yield
		T/A	%	LBS/A
L53 x z6	Fast IN - RS	13.7 a	11.6 a	3178 a
L53 x z5	Slow IN - RS	13.3 a	12.4 a	3298 a
y225	Fast IN - Mass	10.7 a	12.7 a	2717 a
y246	Slow IN - Mass	10.3 a	11.7 b	2410 a

Table 5. Root yield, sucrose percentage and sugar yield of leaf initiation (IN) and stress selections (ST) using recurrent selection methods.

Entry	Root Yield	Sucrose	Sugar Yield
	T/A	%	LBS/A
L53cms x High ST sel	17.0 a	12.9 b	4386 a
L53cms x Low ST sel	14.3 a	13.7 a	3918 a
L53cms x Fast IN sel	16.5 a	12.3 a	4257 a
L53cms x Slow IN sel	14.3 a	12.9 a	3775 a
L53cms x High ST & Fast IN	15.6 a	13.0 a	4056 a
L53cms x Low ST & Slow IN	16.2 a	13.3 a	4309 a

ASSESSMENT OF ENDEMIC SYMBIOTIC BACTERIA FOR BIOCONTROL OF SUGARBEET INSECT PESTS

C. A. Wozniak and S. E. Hinz

BSDF Project 641

Relevance of Insect-Endogenous Bacteria (IEB) to Biological Control. Bacteria have engaged other living organisms from all perspectives - pathogen, commensal, symbiote, parasite - with the resultant interaction becoming fixed and selected over time. The presence of mutualistic bacteria within the gut tissues of a variety of insects has been demonstrated to be associated with a normal, healthy state of the insect. The nutrition, development and even fertility of insects have all been influenced by the actions of endogenous microbes.

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* Roder, feeds predominantly on the surface of the root tissue and is usually associated with a 'slime tunnel', that is, the formation of a plant juice exudate supporting microbial growth. Larval SBRM have been observed to feed on this slime and ingest it into their gut. An examination of the oral (cibarium, pharynx) region of this insect suggests that it is well suited for this type of particulate feeding and may not be readily considered a truly phytophagous insect species. Our examinations of the uptake of variously sized latex spheres (with fluorescent tags) indicated that bacterial cell- and endospore-sized particulates could be selectively ingested during feeding. With this in mind, we analyzed the microflora of SBRM larvae from five states.

As in the study of Iverson et al. (*Appl. Env. Micro.* 47:22-27, 1984), a reproducible number of IEB species were recovered from SBRM collected from the Red River Valley. In order to assess the similarity of the microbial communities associated with SBRM in four different regions, third instar larvae were surface disinfested and bacteria isolated for identification. The common occurrence of some of these bacterial species in insects from diverse origins is suggestive of some functional role for the microbes. We noted, however, that only a single species, *Stenotrophomonas maltophilia* (formerly *Xanthomonas-* and *Pseudomonas- maltophilia*), was recovered from insects at all locations. At least 53 IEB species were identified from third instar samples; several isolates remained unidentifiable following biochemical and microbiological tests. The vast majority of these species were recovered infrequently and therefore were not considered in further assessments.

Rhizospheric Bacteria of Sugarbeet. To evaluate the presence of various bacteria on the root surface in the absence of insects (which may inoculate roots during feeding), 6' x 3' screened cages were placed over newly planted rows. Sticky stakes were placed within the cages to determine the ingress of insects. Roots were pulled throughout the season, brushed free of soil and immersed in phosphate buffered saline-Tween 20. Plating of root washings and internal tissue samples on selective and general bacteriological media yielded numerous species, many of which were identical to those found within SBRM. *S. maltophilia* (Sm) was found to be present on all sugarbeet roots examined from these Red River Valley samples.

SBRM - IEB Co-culture System. Surface disinfestation of SBRM eggs removes microbial inoculum from the chorion and results in a gnotobiotic or germ-free maggot. Following treatment with detergent (Tween-20/Triton X-100), hypochlorite (0.2%) and buffered washings, eggs were allowed to hatch at 24^0 C on Murashige and Skoog plant tissue culture medium supplemented with 3% sucrose (MS0) and solidified with 0.3% Gelrite. Axenic suspension cell cultures (in MS0) of sugarbeet lines 'REL-1' or 'EL48' were then added (2.0 ml) to solid medium containing SBRM eggs. At approximately 25% hatch (usually 3 to 4 days), bacterial or media (control) treatments were applied to plates. Bacterial inoculum was grown overnight in Luria-Bertani broth supplemented with 0.5% sucrose (LBS5) at 210 rpm, 28^0 C (*Serratia liquefaciens*, *Pseudomonas syringae* pv. *aptata*, *S. maltophilia*) or 37^0 C (*Escherichia coli*). Broth cultures were diluted 1:19 with LBS5, adjusted to 0.15 - 0.20 at $A590_{nm}$, and 200 or 400 μl added per dish (2 to 8 x 10^7 cfu/plate). A 0.2 μm filtrate of Sm broth culture and LBS5 medium were included as microbe-free treatments.

Of the four species of IEB evaluated, all were found capable of stimulating moulting of first instar larvae through to the third (final) instar. Development of second instars proceeded during the second and third weeks of co-culture; this time frame is in accord with field observations concerning developmental timing. Production of third instar larvae was initially noted during the third week in some cultures; however, many plates did not give rise to final instars until 4 to 5 weeks, or not at all.

Bacteria added to the SBRM-sugarbeet cell co-culture were observed to associate with callus clumps and ramify through slime tunnels within the medium; however, the paucity of reduced nitrogen and organic substrates within MS0, acid pH (5.7), and the reduced temperature prevented a general overgrowth of the culture. *Ps. syringae* pv. *aptata*, a pathogen of sugarbeet, did however, manage to grow into a congruous lawn that had a negative affect on cell growth. Despite this apparent deleterious influence on sugarbeet cell growth, maggots cultured in the presence of this bacterium were vigorous and robust. Whether this reflects the *in vitro* multiplication of bacterial cells, their influence on sugarbeet cells or a direct mediation of SBRM nutrition cannot be discerned from these experiments. Over 40% of first instars cultured on REL-1 cells in the presence of *Ps. syringae* pv. *aptata* yielded third instar moults.

E. coli JM109 and *S. liquefaciens* ATCC 27592 were found to support SBRM larval development; however, larvae were not as large or active in the presence of these species. It must be pointed out that although initial inoculum levels of the four bacteria were similar, variation in colonization of sugarbeet cells and the medium surface, incorporation and fate within the larval gut, and ramification within slime tunnels all influence the ultimate cfu density within the plate. This may explain the observed death of many second instars and the survival of fewer third instars within plates inoculated with *S. liquefaciens*.

Sm isolates '2P16A718' from larval SBRM (Powell,WY), ATCC 13637 (pharyngeal sample; type strain), '2M14A822' from larval SBRM (Hillsboro, ND) and '2E6A' from the SBRM egg rearing program all were capable of providing a moulting factor required by SBRM to attain the final instar stage *in vitro*. Additionally, the relative rate of moulting was more in line with that expected from field data (*e.g.*, 10 days to second instar, 23 to 30 days to third instar). Almost 35% of first instar larvae reached second instar stage in the presence of Sm and over 35% of these reached third (final)

instar. A few of the more vigorous moults are currently in cold storage (mandatory diapause) with one actively feeding almost a year since hatching.

Control treatments in which sugarbeet cells or bacteria or both were not added to the co-culture system resulted in a cessation of development at the first instar in most instances. In the presence of axenic suspension cells, but without added bacteria, a small number of larvae (approx. 21%) moulted to the second instar but failed to develop further. We are currently assessing microbial sterility (*i.e.*, absence from larvae) by polymerase chain reaction (PCR)-mediated amplification of a 16S rDNA-intergenic spacer region with primers derived from Sm ATCC 13637. This is necessary to preclude the presence of atypical or non-culturable eubacteria that would not have been detected by standard isolation procedures but could be present within SBRM.

When SBRM-sugarbeet cell co-cultures were amended with a 0.2 μm culture filtrate from Sm '2P16A718' broth culture (LBS5, 28^0 C), third instar larvae were obtained within the six week time frame of the experiment. Although the percentage varied between plates and experiments (*i.e.*, 0% to 19%), the development of third instars stimulated by a cell-free filtrate suggests that the moulting factor(s) responsible is soluble and secreted into the medium during bacterial growth. We are currently analyzing this factor by physical and chemical treatments of the filtrate.

During co-cultivation of sugarbeet tissue and IEB, sugarbeet root tissues were readily consumed in the presence of SBRM larvae and bacteria. In the absence of bacteria, however, larvae were observed to feed but with little effect on sugarbeet tissue growth. We are currently examining the influence of bacterial inoculum on growth of sugarbeet tissues *in vitro* in the absence of SBRM to quantify the net consumption of tissue by larvae versus growth reduction from non-specific bacterial influences.

In addition to realizing significant information regarding the interaction between the SBRM, associated bacteria and the sugarbeet root, the co-culture system provides a unique opportunity to introduce biopesticidal agents for evaluation. For example, the presentation of endospores and protein crystals of *Bacillus thuringiensis* (Bt) to insects during bioassays is critical but difficult to assess. An actively feeding larva within a co-culture system would more likely represent a realistic situation within which to encounter such an agent as opposed to a filter paper disc. Similarly, defined chemical agents could be precisely quantified and applied for contact with larval insects with the added advantage of an observation chamber for assessment.

Strain Analysis - *S. maltophilia*. Conserved areas of genomic DNA sequence may be useful in distinguishing variants of organisms, such as bacteria of one species from diverse origins. With this goal of grouping Sm isolates in mind, we examined three sequence groups known to exist in gram negative bacteria. Repetitive Extragenic Palindromic (REP), Enterobacteriaceae Repetitive Intergenic Consensus (ERIC), and 16S ribosomal DNA - intergenic spacer region (16S rDNA-IGS) sequences were selectively amplified by the design of heterologous oligonucleotide primers with varying degrees of degeneracy encoded by inosine bases. Total DNA preparations of 120 isolates of Sm representing IEB, root, and clinical strains were used as templates in PCR-mediated amplifications.

The products from PCR were separated on 1.6% MetaPhor agarose and visualized with ethidium bromide staining. REP-like products were present as 1 to 3 bands of approximately 300 to 900 bp; however, their production was inconsistent within and between strain groups (*e.g.*, IEB from one location) or amplification was simply poor to non-existent. In contrast, ERIC-like sequences yielded reproducible and simple patterns of PCR products in the range of 400 to 2000 bp; typically two to five products were resolved per strain. Southern hybridization data, although preliminary, suggests that all amplifications were based on recognition of ERIC sequences and were not the result of cross annealing under relaxed thermal cycling conditions. The initiation of extension within ERIC sequences in an inverse PCR scheme may prove useful in identifying genes of the transcribed regions within which they reside.

The amplification of a conserved region such as the 16S rDNA gene and IGS yielded simple patterns of two to four products which were produced in similar profile within most strains. This was expected from previous work on highly conserved regions. Our analysis will now focus on restriction digest patterns of these PCR products as a means of detecting small differences in sequence homology. Ultimately we will utilize PCR based detection schemes to identify strain origins rapidly, as opposed to cumbersome and expensive biochemical analyses.

PUBLICATIONS

Abstracts of Papers Published or Approved for Publication.

Engelkes, C.A., and Windels, C.E. 1994. β-escin (saponin), oat seedlings, and oat residue in soil affects growth of *Aphanomyces cochlioides* hyphae, zoospores, and oogonia. Phytopathology 84:1158.

To understand how an oat precrop suppresses Aphanomyces damping-off of sugar beet, *A. cochlioides* was exposed to β-escin (a saponin related to that produced by oat), volatiles and extracts from oat decomposing in soil, and oat seedlings. After 48 hr, hyphal growth of 13 isolates was reduced 31-100% with increasing β-escin concentrations (50-2500 ppm) in media compared to the PDA control. After 48 hr exposure to volatiles produced as oat decomposed in soil, hyphal growth on PDA was reduced 20-38% compared to the controls. By 24 hr after *A. cochlioides* was added to distilled water with 10 ppm β-escin, oat seedlings, or extracts from oat residue decomposing in soil, zoospores germinated and abundant oogonia formed. Formation of zoosporangia was delayed in 100 ppm β-escin; no zoosporangia or oogonia formed in 1000 ppm β-escin. Thus, an oat precrop directly affects growth of hyphae, zoospores, and oogonia of *A. cochlioides*.

Engelkes, C.A., and Windels, C.E. 1995. Oat precrops, soil moisture, and fertility affect suppression of Aphanomyces damping-off. Phytopathology 85:(In press).

Oat suppresses Aphanomyces damping-off of sugar beet. We examined effects of number and timing of oat precrops, moisture, and fertility on disease in the greenhouse. Oat (O) was grown 4 wk in four field soils (#2, 5, 10, 11) infested with *Aphanomyces cochlioides* or left fallow (F) for two cycles (F-F, O-F, F-O, O-O). Plants were cut, incorporated into soils, and incubated 3 wk (20-30% water by wt). Root rot indices (RRI, 0=healthy, 100=plant dead) in subsequent beet plantings in the four soils averaged 69 for F-O and O-O and 87 for O-F and F-F. In soil 10, O-O (RRI=13) decreased disease more than F-O (RRI=35); in soil 11, no pretreatment suppressed disease (RRI≥95). Reduction of moisture in soil 11 to 10% during oat decomposition and beet growth lowered RRI of beets to 21 compared to 80 in fallow controls. Disease also was suppressed when soils, precropped with oat or left fallow, were fertilized (20:20:20) prior to beet emergence (RRI=15) compared to the unfertilized fallow control (RRI=93). Thus, suppression of damping-off of sugar beet with an oat precrop is enhanced by lower soil moisture, fertilizer applications, and sometimes by planting two precrops.

Engelkes, C.A., and Windels, C.E. 1995. Suppression of Aphanomyces damping-off of sugarbeet affected by soil moisture and rotation precrops. J. Sugar Beet Res. 32:(In press).

Soil-incorporation of 4-wk-old oat into soil infested with *Aphanomyces cochlioides* reduces damping-off of sugarbeet in the greenhouse. Our objectives were to evaluate 1) effects

of soil moisture during oat decomposition (3 wk) and sugarbeet growth (4 wk) on disease and 2) direct effects of volatiles and extracts from several crops on hyphae, zoospores, and oogonia of *A. cochlioides*. When two sandy loam soils were watered to field carrying capacity (FCC, 25% water by weight), root rot indices (RRI, 0=healthy, 100=plants dead) of beets were the same in soils precropped to oat or that were fallow (RRI≥95). Reduction of soil moisture to 10% of FCC lowered RRI of beets to 21 when oat was a precrop compared to 80 when soil was previously fallow. When soil-incorporated precrops and controls (sugarbeet, fallow soil) had decomposed for 5 days in desiccators, *A. cochlioides* was exposed to resulting volatiles. After 48 hr, hyphae grew 0.8 cm with barley and sweet corn, 1.1 cm with oat and wheat, 1.4 cm with sugarbeet, and 1.5 cm with fallow soil. Exposure of *A. cochlioides* for 48 hr to root extracts of sugarbeet resulted in germination of zoospores and production of abundant oogonia, which all had antheridia. In comparison, oat root extracts resulted in lysis of zoospores and oogonia had few or no antheridia; wheat root extracts and water controls resulted in motile zoospores and reduced numbers of oogonia with antheridia. In conclusion, effectiveness of a green oat precrop is affected by soil moisture; some precrops directly reduce growth of *A. cochlioides*.

Volatiles, produced as oat decomposed in soil, reduced hyphal growth of five isolates of *A. cochlioides* 20-38% compared to controls. Oat seedlings and extracts from decomposing oat residue caused germination of zoospores of *A. cochlioides* within 24 hr of exposure; oogonia formed, but few if any antheridia formed within 48 hr of exposure. Water controls caused no detrimental effects on zoospores; oogonia and antheridia formed abundantly within 48 hr of exposure. Thus, populations of *A. cochlioides* may be decreased in the field by antagonistic microorganisms acting on the unfertilized oogonia and by a delay in formation of oospores (the thick-walled survival structure of this fungus).

Environmental Conditions Affecting Suppression - An oat precrop was grown in four sandy loam soils (infested with *A. cochlioides*) with a field carrying capacity (FCC) of 20-30% water by weight. When oat residues decomposed for 3 and 10 wk prior to planting sugarbeet, root rot indices (RRI, 0=healthy, 100=plant dead) of sugarbeet averaged 69 to 85, respectively, compared to the fallow control (RRI=88). In one of four soils, a double versus single oat precrop enhanced disease suppression (RRI=13 and 35, respectively) compared to the fallow control (RRI=73). In a soil watered to FCC during oat decomposition and sugarbeet growth, an oat precrop caused no suppression of disease compared to the fallow control (RRI≥95%). Decreasing the moisture of this soil from 20 to 10% by weight decreased the RRI by 72% in the oat precrop treatment and 18% in the fallow control.

Aphanomyces damping-off was suppressed when three sandy loam soils, precropped with oat or left fallow, were fertilized with Peters 20:20:20 fertilizer during oat growth (4 wk) and/or prior to sugarbeet emergence (RRI=15) compared to the unfertilized fallow control (RRI=93). We are determining if nitrogen, phosphorus, potassium, or a fertilizer combination is enhancing disease suppression with an oat precrop.

SUPPRESSION OF APHANOMYCES DAMPING-OFF OF SUGARBEET BY AN OAT PRECROP[1]
(BSDF Project 650)

C. A. Engelkes and C. E. Windels

Aphanomyces cochlioides is a soilborne fungus that infects roots of sugarbeet throughout the growing season. Postemergence damping-off of seedlings can result in devastating stand losses and taproot tip rot of older sugarbeet plants can result in yield losses and lower sugar quality. This is the most serious sugarbeet disease in the Red River Valley and west central Minnesota in seasons with high soil moisture and warm temperatures. Cultural practices and disease-tolerant sugarbeet varieties are of limited effectiveness in controlling Aphanomyces diseases and no seed treatment fungicides are registered for use in the United States.

Aphanomyces damping-off of sugarbeet has been suppressed in the greenhouse by a green oat (*Avena sativa*) precrop. Objectives of our research are to determine the mechanisms of suppression of Aphanomyces damping-off of sugar beet by a green oat crop and the required environmental conditions for activity.

Soil collected from 11 sugarbeet fields naturally infested with *A. cochlioides* was assayed in 1993 to confirm population levels and obtain fresh cultures of the pathogen. Root rot indices (0=healthy, 100=plants dead) of sugarbeet growing in these soils ranged from 34 to 100. For subsequent experiments, four of the 11 field soils were selected which had a high population of *A. cochlioides* and a low population of the fungus *Rhizoctonia solani* AG-2-2 (causal agent of sugarbeet root and crown rot). A 4-wk-old oat precrop suppressed Aphanomyces damping-off of sugarbeet 24-79% in two of the four soils compared to fallow controls.

Mechanisms of Suppression - To understand how an oat precrop affects growth of hyphae, zoospores, and oogonia of *A. cochlioides*, isolates of this fungus were exposed to ß-escin (an antimicrobial compound related to the saponins produced by oat), volatiles and extracts from oat decomposing in soil, and oat seedlings. Media amended with increasing concentrations of ß-escin (50-2500 ppm) reduced hyphal growth of 12 isolates of *A. cochlioides* by 31-100% after 48 hr compared to unamended media. Reduction in hyphal growth caused by ß-escin (250-2500 ppm) was generally a temporary effect. Growth rates after 72 hr were similar or only slightly reduced when hyphae of eight isolates, grown for 14 days on media amended with ß-escin (1000 ppm) and unamended media, were transferred to unamended media.

PUBLICATIONS

Abstracts of Papers Published or Approved for Publication.

Engelkes, C.A., and Windels, C.E. 1994. β-escin (saponin), oat seedlings, and oat residue in soil affects growth of *Aphanomyces cochlioides* hyphae, zoospores, and oogonia. Phytopathology 84:1158.

To understand how an oat precrop suppresses Aphanomyces damping-off of sugar beet, *A. cochlioides* was exposed to β-escin (a saponin related to that produced by oat), volatiles and extracts from oat decomposing in soil, and oat seedlings. After 48 hr, hyphal growth of 13 isolates was reduced 31-100% with increasing β-escin concentrations (50-2500 ppm) in media compared to the PDA control. After 48 hr exposure to volatiles produced as oat decomposed in soil, hyphal growth on PDA was reduced 20-38% compared to the controls. By 24 hr after *A. cochlioides* was added to distilled water with 10 ppm β-escin, oat seedlings, or extracts from oat residue decomposing in soil, zoospores germinated and abundant oogonia formed. Formation of zoosporangia was delayed in 100 ppm β-escin; no zoosporangia or oogonia formed in 1000 ppm β-escin. Thus, an oat precrop directly affects growth of hyphae, zoospores, and oogonia of *A. cochlioides.*

Engelkes, C.A., and Windels, C.E. 1995. Oat precrops, soil moisture, and fertility affect suppression of Aphanomyces damping-off. Phytopathology 85:(In press).

Oat suppresses Aphanomyces damping-off of sugar beet. We examined effects of number and timing of oat precrops, moisture, and fertility on disease in the greenhouse. Oat (O) was grown 4 wk in four field soils (#2, 5, 10, 11) infested with *Aphanomyces cochlioides* or left fallow (F) for two cycles (F-F, O-F, F-O, O-O). Plants were cut, incorporated into soils, and incubated 3 wk (20-30% water by wt). Root rot indices (RRI, 0=healthy, 100=plant dead) in subsequent beet plantings in the four soils averaged 69 for F-O and O-O and 87 for O-F and F-F. In soil 10, O-O (RRI=13) decreased disease more than F-O (RRI=35); in soil 11, no pretreatment suppressed disease (RRI≥95). Reduction of moisture in soil 11 to 10% during oat decomposition and beet growth lowered RRI of beets to 21 compared to 80 in fallow controls. Disease also was suppressed when soils, precropped with oat or left fallow, were fertilized (20:20:20) prior to beet emergence (RRI=15) compared to the unfertilized fallow control (RRI=93). Thus, suppression of damping-off of sugar beet with an oat precrop is enhanced by lower soil moisture, fertilizer applications, and sometimes by planting two precrops.

Engelkes, C.A., and Windels, C.E. 1995. Suppression of Aphanomyces damping-off of sugarbeet affected by soil moisture and rotation precrops. J. Sugar Beet Res. 32:(In press).

Soil-incorporation of 4-wk-old oat into soil infested with *Aphanomyces cochlioides* reduces damping-off of sugarbeet in the greenhouse. Our objectives were to evaluate 1) effects

of soil moisture during oat decomposition (3 wk) and sugarbeet growth (4 wk) on disease and 2) direct effects of volatiles and extracts from several crops on hyphae, zoospores, and oogonia of *A. cochlioides*. When two sandy loam soils were watered to field carrying capacity (FCC, 25% water by weight), root rot indices (RRI, 0=healthy, 100=plants dead) of beets were the same in soils precropped to oat or that were fallow (RRI$\geq$95). Reduction of soil moisture to 10% of FCC lowered RRI of beets to 21 when oat was a precrop compared to 80 when soil was previously fallow. When soil-incorporated precrops and controls (sugarbeet, fallow soil) had decomposed for 5 days in desiccators, *A. cochlioides* was exposed to resulting volatiles. After 48 hr, hyphae grew 0.8 cm with barley and sweet corn, 1.1 cm with oat and wheat, 1.4 cm with sugarbeet, and 1.5 cm with fallow soil. Exposure of *A. cochlioides* for 48 hr to root extracts of sugarbeet resulted in germination of zoospores and production of abundant oogonia, which all had antheridia. In comparison, oat root extracts resulted in lysis of zoospores and oogonia had few or no antheridia; wheat root extracts and water controls resulted in motile zoospores and reduced numbers of oogonia with antheridia. In conclusion, effectiveness of a green oat precrop is affected by soil moisture; some precrops directly reduce growth of *A. cochlioides*.

SUPPRESSION OF APHANOMYCES DAMPING-OFF OF SUGARBEET BY AN OAT PRECROP[1]
(BSDF Project 650)

C. A. Engelkes and C. E. Windels

Aphanomyces cochlioides is a soilborne fungus that infects roots of sugarbeet throughout the growing season. Postemergence damping-off of seedlings can result in devastating stand losses and taproot tip rot of older sugarbeet plants can result in yield losses and lower sugar quality. This is the most serious sugarbeet disease in the Red River Valley and west central Minnesota in seasons with high soil moisture and warm temperatures. Cultural practices and disease-tolerant sugarbeet varieties are of limited effectiveness in controlling Aphanomyces diseases and no seed treatment fungicides are registered for use in the United States.

Aphanomyces damping-off of sugarbeet has been suppressed in the greenhouse by a green oat (*Avena sativa*) precrop. Objectives of our research are to determine the mechanisms of suppression of Aphanomyces damping-off of sugar beet by a green oat crop and the required environmental conditions for activity.

Soil collected from 11 sugarbeet fields naturally infested with *A. cochlioides* was assayed in 1993 to confirm population levels and obtain fresh cultures of the pathogen. Root rot indices (0=healthy, 100=plants dead) of sugarbeet growing in these soils ranged from 34 to 100. For subsequent experiments, four of the 11 field soils were selected which had a high population of *A. cochlioides* and a low population of the fungus *Rhizoctonia solani* AG-2-2 (causal agent of sugarbeet root and crown rot). A 4-wk-old oat precrop suppressed Aphanomyces damping-off of sugarbeet 24-79% in two of the four soils compared to fallow controls.

Mechanisms of Suppression - To understand how an oat precrop affects growth of hyphae, zoospores, and oogonia of *A. cochlioides*, isolates of this fungus were exposed to ß-escin (an antimicrobial compound related to the saponins produced by oat), volatiles and extracts from oat decomposing in soil, and oat seedlings. Media amended with increasing concentrations of ß-escin (50-2500 ppm) reduced hyphal growth of 12 isolates of *A. cochlioides* by 31-100% after 48 hr compared to unamended media. Reduction in hyphal growth caused by ß-escin (250-2500 ppm) was generally a temporary effect. Growth rates after 72 hr were similar or only slightly reduced when hyphae of eight isolates, grown for 14 days on media amended with ß-escin (1000 ppm) and unamended media, were transferred to unamended media.

Volatiles, produced as oat decomposed in soil, reduced hyphal growth of five isolates of *A. cochlioides* 20-38% compared to controls. Oat seedlings and extracts from decomposing oat residue caused germination of zoospores of *A. cochlioides* within 24 hr of exposure; oogonia formed, but few if any antheridia formed within 48 hr of exposure. Water controls caused no detrimental effects on zoospores; oogonia and antheridia formed abundantly within 48 hr of exposure. Thus, populations of *A. cochlioides* may be decreased in the field by antagonistic microorganisms acting on the unfertilized oogonia and by a delay in formation of oospores (the thick-walled survival structure of this fungus).

Environmental Conditions Affecting Suppression - An oat precrop was grown in four sandy loam soils (infested with *A. cochlioides*) with a field carrying capacity (FCC) of 20-30% water by weight. When oat residues decomposed for 3 and 10 wk prior to planting sugarbeet, root rot indices (RRI, 0=healthy, 100=plant dead) of sugarbeet averaged 69 to 85, respectively, compared to the fallow control (RRI=88). In one of four soils, a double versus single oat precrop enhanced disease suppression (RRI=13 and 35, respectively) compared to the fallow control (RRI=73). In a soil watered to FCC during oat decomposition and sugarbeet growth, an oat precrop caused no suppression of disease compared to the fallow control (RRI≥95%). Decreasing the moisture of this soil from 20 to 10% by weight decreased the RRI by 72% in the oat precrop treatment and 18% in the fallow control.

Aphanomyces damping-off was suppressed when three sandy loam soils, precropped with oat or left fallow, were fertilized with Peters 20:20:20 fertilizer during oat growth (4 wk) and/or prior to sugarbeet emergence (RRI=15) compared to the unfertilized fallow control (RRI=93). We are determining if nitrogen, phosphorus, potassium, or a fertilizer combination is enhancing disease suppression with an oat precrop.

SUGARBEET RESEARCH

1994 Report

Section E

Sugarbeet and Bean Research Unit
Agricultural Research Service, USDA
East Lansing, Michigan

Dr. J. C. Theurer, Research Geneticist, Plants
Dr. J. W. Saunders, Research Geneticist, Plants
Dr. J. M. Halloin, Plant Physiologist

Cooperation:

Michigan Agricultural Experiment Station
Michigan Sugar Company
Monitor Sugar Company

CONTENTS

ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION

HALLOIN, J.M. and C.A. ELLIGER. <u>Characterization, localization and toxicity of phenolic phytoalexins associated with crown and root rot lesions caused by rhizoctonia solani in sugarbeets</u>. Plant Sci. 99:223-38. 1994

The phenolic phytoalexins betagarin and betavulgarin occur in association with foliar lesions of sugarbeets (Beta vulgaris L.) caused by Cercospora beticola. We studied phytoalexins associated with disease lesions caused by Rhizoctonia solani (AG 2-2) on crowns and roots of sugarbeets. Infected tissues contained betagarin and betavulgarin, as well as two new compounds that are a glucoside and a xyloside of betavulgarin. Only trace amounts of these compounds were isolated from healthy tissues surrounding disease lesions. Growth of R. solani on agar media containing these phytoalexins revealed that only betavulgarin caused inhibition of radial growth of the fungus. Chemical assays showed that agar medium containing betavulgarin, on which the fungus had grown, contained noninhibitory betavulgarin glycosides, demonstrating that the fungus detoxifies the phytoalexin via glycosylation. Diseased tissues fail to accumulate betavulgarin at concentrations that are highly inhibitory to the fungus, apparently due to this detoxification. We propose that glycosylative detoxification of phenolic phytoalexins may be of widespread occurrence in plants infected by R. solani.

HALLOIN, J.M and C.A. ELLIGER. <u>Characterization, localization and biological activity of phytoalexins associated with rhizoctonia root rot lesions</u>. Proceeding, 1995 Mtg. Am. Society of Sugar Beet Technologists, New Orleans, LA. March 8-12. In Press.

The phenolic phytoalexins betagarin and betavulgarin occur in association with foliar lesions of sugarbeets (Beta vulgaris L.) caused by Cercospora beticola. We studied phytoalexins associated with disease lesions caused by Rhizoctonia solani (AG 2-2) on crowns and roots of sugarbeets. Freeze-dried tissues were extracted with methanol, and the phytoalexins were purified by HPLC. A phytoalexin localized within healthy tissues surrounding disease lesions, that forms colored nitrous derivatives upon reaction with dilute nitrous acid, was not extracted by methanol, apparently due to cross linking with other plant constituents. Infected tissues contained betagarin and betavulgarin, as well as two new compounds that are a glucoside and a xyloside of betavulgarin. Only trace amounts of these compounds were isolated from healthy tissues surrounding disease lesions. Growth of R. solani on agar media containing these phytoalexins revealed that only betavulgarin caused inhibition of radial growth of the fungus. Chemical assays showed that agar medium containing betavulgarin, on which the fungus had grown, contained non inhibitory

betavulgarin glycosides, demonstrating that the fungus detoxifies the phytoalexin via glycosylation. Diseased tissues fail to accumulate betavulgarin at concentrations that are highly inhibitory to the fungus, apparently due to this detoxification.

HALLOIN, J.M., and J.C. THEURER. Procedure modifications for operation of the rhizoctonia crown and root rot Nursery in East Lansing, MI. Proceeding, 1995 Mtg. Am. Society fo Sugar Beet Technologists, New Orleans, LA. March 8-12. In Press.

Two changes have been made in the operation of the rhizoctonia crown and root rot nursery at East Lansing, MI. An alternate disease rating system has been developed and the crop rotation sequence has been changed to facilitate establishment of epiphytotics. The new rating system is non linear, providing numerical expansion of those categories exhibiting little rot. Roots are scored: 0=no evidence of disease, 1=few isolated lesions, 2=coalescing lesions covering up to 10% of root surface, 3=up to 25% of root rot and 4=over 25% root rot. While not useful for disease loss estimates, this non linear system should provide better numerical discrimination for selection of resistant roots. In the disease nursery we have recently encountered difficulty in establishing disease epiphytotics severe enough to discriminate resistant from partially resistant germplasms. Experiments were done to determine if biological control of the pathogen was responsible for low disease severity. In two of three years, the disease was more severe at new sites not previously used as disease nurseries than in the established nursery. Biological control of Rhizoctonia seems a likely cause of the decreased disease severity in the established nursery. The crop rotation for the nursery site is being changed from sugarbeets/alfalfa to a three year rotation of sugarbeets/oats/navy beans, in an attempt to reduce the apparent effects of biological control of Rhizoctonia.

ELLIGER, C.A., and J.M. HALLOIN. Phenolics induced in beta vulgaris by rhizoctonia solani infection. Phytochemistry 37:691-93. 1994

Rhizoctonia solani incubated sugarbeet roots produced the new xyloside and glucoside of 2'-hydroxy-6, 7-methylenedioxy -5-methoxyisflavone (betavulgarin) in response to infection. Also, formed were 6, 7-methylendedioxy- 5-methoxydihydro-flavonol and 3'-methoxy-4', 5, 7-trihydroxydihydroflavonol, not reported previously in B. vulgaris.

SAUNDERS, J.W., TSAI, C.J., and E. SAMPER. Alternative sole nitrogen and carbon sources for sugarbeet tissue culture and possible somatic cell selection.

We examined the ability of four sugarbeet processing impurity chemical components and galactose to serve as sole carbon (C)

source, and of eight endogenous compounds to serve as sole nitrogen (N) source for culture of sugarbeet clone REL-1 in vitro. Raffinose was similar to sucrose in support of suspension culture plate-out (SP) growth, callus initiation with shoot regeneration from leaf discs, and shoot culture (SC). Galactose was moderately supportive of SP growth but was inadequate for leaf disc callusing and SC. Glutamine (GLN), glutamate (GLU) and glycine betaine (BET) were ineffective as sole C sources. Nitrate, ammonium, GLN and urea, all at 60 mM N, were moderately supportive of SP and SC growth compared to the nitrate-ammonium mix in MS medium. Proline was poorly supportive of SP and SC growth, and choline and BET were ineffective. GLU was effective only in support of SP growth. SP tissue ability to utilize raffinose, GLN and GLU may preclude their use as sole C, N and N source respectively in media in attempts to select for biochemical mutants that accumulate less of these processing impurities. BET utilizing mutants might, however, be selectable with BET as sole N or C source. Additionally, reliance on single N sources would render cells vulnerable to inhibitors of steps in N assimilation and permit selection of cells resistant to those inhibitors, with recovery of mutants in N assimilation.

HOUSEMAN, K.S. and J.W. SAUNDERS. Nonspecific oxidoreductase found by starch gel electrophoresis in callus but not foliage of sugarbeet and several other species. Agronomy Abstract. pp. 205.

Enzyme activity bands found following starch gel electrophoresis of crude extracts of callus, but not of foliage, in several sugarbeet, dry bean, soybean, carrot and potato germplasm sources were visualized in the same species specific band locations when each of five different dehydrogenase stains were employed. The same bands, three for dry bean and one each for the other species, were present when the respective dehydrogenase substrates were absent from the reaction mixture. In these cases, the inclusion of 320 mM ethanol greatly intensified the bands. In sugarbeet the band was also found following Sephadex (G25) filtration of the crude extract. The presence of 41 mM mersalyl acid or 1.0 mM pyrazole (reported as inhibitors, respectively, of some mitochondrial NAD(P)H dehydrogenase and of alcohol dehydrogenase) in the malate dehydrogenase stain (MDH) eliminated the non-specific band(s) but did not affect specific MDH bands. Recognition of these non-specific bands may raise questions concerning the accuracy of some previous isozyme studies involving callus published in the literature.

TSAI, C.J. and J.W. SAUNDERS. Growth regulator and genotype effects on somatic embryogenesis from sugarbeet callus. Proceeding, 1995 Mtg. Am. Society fo Sugar Beet Technologists, New Orleans, LA. March 8-12. In Press.

Opaque white somatic embryos up to 4 mm long were elicited from hormone autonomous sugarbeet (Beta vulgaris L.) callus within 5 weeks following plating of fresh suspension cultures grown on hormone free MS medium onto further hormone free MS medium. Suspension cultures had been initiated from approximately one month old leaf disc callus formed on MS + 1.0 mg/l 6-benzyladenine. The inclusion Of 0.1 - 0.3 mg/l abscisic acid in the plate out medium significantly increased the production of somatic embryos. Maximum average somatic embryo yield observed was 77 per ml of suspension plated out (minimum size for counting, 0.5 mm). Most somatic embryos developed into plantlets, often with betalain pigmentation on hypocotyls, after transfer onto hormone free MS medium. Genotype strongly influenced yield of somatic embryos.

THEURER, J.C. and J.W. SAUNDERS. Row spacinng and plant density effect on smooth root sugarbeets. J. Sugar Beet Res. 32: (Accepted). March 1995

Agronomic performance of smooth root (SR) type sugarbeet genotypes was compared with that of standard commercialcultivars under different row spacings and plant densities during the years 1988-1990. In one experiment smooth root types SR 87 and 87H1-00 were compared with commercial cultivars Mono-HY-E4 (MH E4) and ACH 176 in plant population densities of approximately 69,200, 96,800, and 79,100 plants per hectare. Individual plant spacings were 71 cm (between rows) x 20 cm (between plants within rows), 56 x 20 cm, and 46 x 46 cm respectively. In a second experiment in 1989, SR 87 was compared with MH E4 at six plant spacings of 71 x 30 cm, 56 x 30 cm, 46 x 30 cm, 71 x 15 cm, 56 x 15 cm, and 46 x 15 cm. This experiment was repeated in 1990 with these six plus two additional plant densities, 51 x 30 cm and 51 x 15 cm. Although SR sugarbeets have a different fibrous root system than today's standard root type, there were no adverse effects of SR plants when grown in narrow rows under higher plant densities compared with present conventional 71 cm row width. Results indicated that smooth root sugarbeet genotypes respond to plant density in different environments similarly to adapted standard root commercial cultivars. SR productivity was actually enhanced when sugarbeets were grown at the higher density of 71,760 plants per ha (46 x 30 cm row width).

THEURER, J.C. and J.W. SAUNDERS. <u>Notice of release of monogerm cercospora leafspot resistant sugarbeet Germplasm EL50</u>.

EL 50, a monogerm line with extremely high Cercospora leafspot resistance, was released to sugarbeet industry breeders for increasing leafspot resistance of their breeding lines and commercial cultivars. EL 50 was derived from hybridization of two monogerm individual beets (L403-2 and L828) selected from an East Lansing heterogeneous population developed in the 1970's. Monogerm population with high sugar yield and Cercospora leafspot resistance. Beginning with the F2 generation, two cycles of phenotypic recurrent selection of individual beets were made to enhance leafspot resistance. A group of 58 individually selected beets were used for final seed production of this breeder line. EL 50 is a monogerm diploid segregating for red and green hypocotyl color. Parental material was highly self-sterile. Some near O-type plants have been observed in crosses of EL 50 with Owen's annual CMS tester. EL 50 has shown similar root yield and sugar yield and 1% lower sucrose percentage compared to the commercial cultivar Mono-Hy-E4. EL 50 had a leafspot disease index score of 1.6 compared to 2.6 for BETA BG4501 and 3.6 for Mono-Hy-E4 cultivars based on a scale where 0= no symptoms to 5= dead plant.

BIOLOGICAL CONTROL OF RHIZOCTONIA IN THE EAST LANSING CROWN AND ROOT ROT NURSERY

J. M. Halloin and J. C. Theurer

The site used for the disease nursery has been employed for that purpose for more than 20 years. In recent years we have had difficulty producing disease severe enough to discriminate resistant from partially resistant germplasms. The nursery employs a two year rotation between sugarbeets and alfalfa; and annually the sugarbeets are inoculated six weeks after planting, by dispensing into their crowns, millet caryposes on which the fungus has been grown.

Experiments were done to determine if biological control of the pathogen was responsible for low disease severity. Highly susceptible to highly resistant sugarbeet genotypes were planted in the established *Rhizoctonia* disease nursery and in an adjacent field with no prior use as a root rot disease nursery.

In two of three years, the disease was more severe at the new sites than in the established nursery (Table 1). The increases in disease severity at the new sites enabled better discrimination between resistant and susceptible plants. Inoculated plants at the new sites also were more stunted.

Biological control of *Rhizoctonia* seems a likely cause of the decreased disease severity in the established nursery. The crop rotation for the site is being changed to a three year rotation of sugarbeets/oats/navy beans, in an attempt to reduce the apparent effects of biological control of *Rhizoctonia*.

Table 1. Rhizoctonia crown and root rot ratings of inoculated sugarbeets produced in an established disease nursery (L1) and in nearby fields not previously used as Rhizoctonia disease nurseries (L2) in 1992, 1993 and 1994. The 12 lines tested were arbitrarily divided into "susceptible" and "resistant" groups based upon their disease ratings at L1.

Rating group	1992		1993		1994	
	L1	L2	L1	L2	L1	L2
12 lines	2.47 *	3.05	2.62	2.61	3.13 *	3.70
6 "susc." lines	2.84 *	3.52	2.92	3.03	3.30 *	3.74
6 "res." lines	2.09 *	2.58	2.27	2.11	2.95 *	3.66

* An asterisk between two values denotes that they differ at the 0.05 level of significance.

RHIZOCTONIA CROWN AND ROOT ROT EVALUATION FOR COMMERCIAL AND EXPERIMENTAL SUGARBEET HYBRIDS AT EAST LANSING, MI, 1994

J. M. Halloin, J. C. Theurer and Lee Hubble

Seventeen hybrid varieties plus a resistant check (RC = WC90318 = FC701/5) and a susceptible check (SC = USH23)were evaluated for their resistance to *Rhizoctonia* crown and root rot in the disease nursery maintained at East Lansing, MI. Natural inoculum in the soil was supplemented by application of ground millet infected with *R. solani*, which was applied to the crowns of the sugarbeets just prior to layby. Roots were dug by hand in mid September and scored for disease on a scale of 0 = no disease lesions to 4 = dead, or greater than 75 % of the root rotted (= RZ Score). There was very heavy infection in the nursery this year, with all roots containing lesions, and no statistically significant differences in disease severity were noted among the commercial varieties in the test.

Entry #	Variety	RZ Score	% Diseased Plants
1	HM 2718	3.520 AB[*]	100
2	ACH 390	3.680 AB	100
3	Beta 5344	3.497 AB	100
4	MH E9	3.640 AB	100
5	ACH 185	3.535 AB	100
6	Beta 5931	3.465 AB	100
7	MH E10	3.477 AB	100
8	ACH 370	3.318 AB	100
9	Beta 5713	3.628 AB	100
10	MH E17	3.758 A	100
11	ACH 197	3.673 AB	100
12	Beta 5603	3.495 AB	100
13	MH E4	3.528 AB	100
14	ACH 319	3.485 AB	100
15	Beta 5823	3.390 AB	100
16	ACH 308	3.633 AB	100
17	Beta 5315	3.563 AB	100
19	WC90318 (RC)	3.082 B	100
20	USH23 (SC)	3.398 AB	100

[*] Duncan's Multiple Range Test - Means with the same letter are not significantly different at the 0.05 level.

SELECTION FOR HIGH AND FOR LOW PRODUCTION OF PHYTOALEXINS BY SUGARBEET ROOTS - INITIAL EXPERIMENTS

J. M. Halloin

Sugarbeet roots exhibit resistance to crown and root rot caused by *Rhizoctonia solani* at 20°C or less. Similarly, resistance of infected beets in the field is evident at cool temperatures through cessation of rot and subsequent healing responses. These resistances are consistently accompanied by production of phenolic phytoalexins in healthy tissues surrounding rot. Localization and crude quantitation of those phytoalexins can be accomplished via formation of red-colored nitroso derivatives within tissues. A phytoalexin response similar to that elicited by the fungus (most intense at low temperatures) is elicited by 10^{-3}M solutions of mercuric chloride.

The consistent association of phytoalexins with the resistance response to the fungus suggests that phytoalexin formation may be an important determinant of resistance. As part of a program to determine the role of phytoalexins in resistance to crown and root rot, a program of divergent, recurrent selection for phytoalexin production has been initiated. Roots of several inbred lines have been selected, through phytoalexin elicitation with mercuric chloride, for unusually high or low production of phytoalexins. These roots were induced to flower, and further cycles of selection will be done on plants from the resulting seeds. The resulting selections then will be evaluated for resistance to *Rhizoctonia solani* to determine the relationship between phytoalexin production and disease resistance.

For a phytoalexin to be effective in disease resistance, it must be fungitoxic, and there must be enough of it in the appropriate place when it is needed. Thus, experiments also are in progress to identify the compound involved, determine its toxicity, and establish the speed, localization, and quantity of its production. Establishment of these aspects of this phytoalexin, coupled with successful application of the color test in recurrent selection, would provide a useful new technique that could be used in selection for resistance to crown and root rot.

Somatic embryos from callus of sugarbeet biotech clone REL-1

Chia-Jung Tsai and Joseph W. Saunders

Somatic embryogenesis involves the formation of embryo-like structures from somatic, i.e., non-germ, cells. In plant tissue culture, somatic embryos (also referred to as embryoids) have most often been produced from callus or suspension culture cells under appropriate conditions, with genotype dependancy being common. Somatic embryos are currently under investigation in species such as lettuce and celery for use in production of artificial seeds (Gray and Purohit, 1991). Elite highly productive individual genotypes from genetically heterogeneous cultivars or superior-combining male sterile clones would be vegetatively reproduced on a large scale as somatic embryos and delivered to the field following conditioning and coating, or with fluid drilling. Somatic embryos can also be used in genetic transformation applications as exemplified with walnut (McGranahan et al.,1990) and Datura innoxia (Ducrocq et al., 1994). Synthetic seed production as well as gene transfer would be more efficient if somatic embryogenesis also recurred via subsequent cycles whereby multiple new embryos arose from existing ones in self replicating production, termed secondary somatic embryogenesis.

Somatic embryos in sugarbeet were first reported by Atanasov (1976) in suspension cultures. Tetu et al. (1987) reported that multiple hormonal sequences were necessary for the induction and development of somatic embryos from callus. Somatic embryogenesis at a low frequency in callus was reported by Freytag et al. (1988) in all six germplasm sources tested. Kubalakova (1990) described callus from at least one genotype that had maintained its embryogenic ability for three years on media without growth regulators. Somatic embryos were directly produced on sugarbeet zygotic embryos by Tenning et al. (1992), who also observed some direct secondary embryogenesis. Doley and Saunders (1989) reported the simple production and partial germination of somatic embryos from leaf disc callus of a fodder beet cultivar without the use of growth regulators. D'Halluin et al. (1992) used embryogenic callus from seedlings in an Agrobacterium-mediated genetic transformation system for sugarbeet.

REL-1 is a self-fertile diploid sugarbeet clone bred for ease of tissue culture manipulations. It exhibits a high frequency of leaf disc callusing, shoot regeneration from hormone autonomous callus, dispersed suspension cultures and resistance to shoot vitreousness. REL-1 is heterozygous (Mm, Bb, and Rr) for monogermness, annualism, and red hypocotyl, respectively. REL-1 has been used for the recovery of monogenic dominant sulfonylurea herbicide resistance by somatic cell selection (Saunders et al., 1992) and of other mutant traits (Saunders et al., 1990).

We report here (1) the initial success in obtaining somatic embryos from biotech clone REL-1, (2) converting somatic embryos into plantlets, and (3) examination of later stages of somatic embryogeny under scanning electron microscopy.

Materials and methods

All experiments were performed with the diploid sugarbeet (*Beta vulgaris L.*) clone REL-1, released to the public in 1987. REL-1 has been maintained in shoot culture (Saunders, 1982) and is available upon request, either as in vitro shoots, whole plants, or S$_1$ seed.

Culture media

The culture media contained Murashige and Skoog inorganic salts (MS) mineral salts (Murashige and Skoog, 1962), 100 mg/l myo-inositol, 1.0 mg/l thiamine· HCl, 0.5 mg/l nicotinic acid, 0.5 mg/l pyridoxine HCl, and 30 g/l sucrose. Media used in plating out were gelled with 3.5 g/l phytagel. The growth regulators used were: 6-benzyladenine (BA) (1.0 mg/l), 2,3,5-triiodobenzoic acid (TIBA) (1.0 mg/l), 1-naphthaleneacetic acid (NAA) (0.25-1.0 mg/l), and/or (±) *cis, trans*-abscisic acid (ABA) (0.1-1.0 mg/l). The pH was adjusted to 5.95 prior to autoclaving. ABA was filter-sterilized and added into previously autoclaved and partially cooled media. Culture vessels were 125 ml erlenmeyer flasks or 20 x 100 mm Falcon disposable plastic Petri plates. Medium volume per vessel was 35 ml. Flasks were closed with foam caps and aluminum foil. Petri plates were sealed with one layer of Parafilm.

Callus was initiated from leaf discs (8 mm diameter) from partially expanded leaves of greenhouse grown REL-1 on MS medium with 1 mg/l BA (Saunders et al., 1992) and 0.9 % Difco Bacto agar in petri plates at 30 C in the dark. Callus was first seen after one month, and after another month, 2 to 3 g of leaf-disc callus was transferred to liquid hormone-free MS medium in flasks for growth at 21$\pm$2 C in the dark. The suspension cultures were shaken on rotary shakers at 120 rpm to aerate the cultures and to reduce cell cluster size.

After 14 days, suspension cultures used as inoculum were pushed through a stainless steel sieve with 830 μm openings. Sieved suspension cells were washed with hormone free liquid medium and plated on MS media with no growth regulators or with combinations of BA and NAA, or NAA, ABA, and TIBA. Each Petri plate received 1 ml of suspension preparation containing about 0.1 g FW, and was incubated in dim light (less than 5 μmolm^{-2} s^{-1} from fluorescent lamps) at 25 C. Minimum size for an embryoid to be counted was 0.5 mm.

Somatic embryos were transferred onto hormone-free MS medium under light (20-50 μmolm^{-2} s^{-1} from fluorescent lamps) at 25 C. The proportion that developed into normal plantlets with roots.

Analysis of variance was based on a randomized complete block design. The average number of somatic embryos per plate for each medium was subjected to ANOVA, and the least significant difference (LSD) test (=0.05) was performed to permit individual treatment comparisons.

Results and Discussion

A low frequency of somatic embryogenesis, nearly one embryoid per Petri plate, was seen following plating-out of suspension culture cells on hormone-free MS medium. No concentration of NAA or BA subsequently tested either individually or in combination produced significantly more somatic embryos than did the hormone-free medium. Rather, the presence of BA at 0.5 or 1.0 mg/l markedly

reduced the occurance of somatic embryos relative to the hormone-free medium (Fig. 1A). On the other hand, ABA at 0.1 or 0.3 mg/l in the media increased the number of somatic embryos per plate up to eight fold (Fig. 1B). The highest somatic embryo yield of 15 per plate was attained with the combination 1 mg/l NAA and 0.1 mg/l ABA (Fig. 1B). ABA is best known for its positive effects in somatic embryogenesis where it normalizes development and inhibits precocious germination (Ammirato, 1974, 1983). With REL-1, TIBA was not stimulatory to somatic embryogenesis (Fig. 1B), even through Tetu et al. (1987) reported a stimulatory effect on bud formation from callus, as did Doley (1990) with REL-1.

During the first two weeks following plating-out, white or light yellow callus proliferated. From the third to the sixth week, various late stages of somatic embryos, from torpedo to mature opaque white embryos with cotyledons, were clearly distinguishable at the callus surface (Figs. 2A and 2B). The simultaneous occurence of embryoids of different lengths (0.5 to 4 mm) (Fig. 2C) indicated that somatic embryogenesis was not uniform and synchronous. After 40 days, most of the somatic embryos with cotyledons were around 2-3 mm long. Each somatic embryo could be easily separated from the surrounding callus.

After being transferred onto hormone-free MS medium, the cotyledons and radicle of the bipolar embryoids gradually developed into shoots and roots simultaneously to form normal plantlets (Fig. 2D). The germination rate of somatic embryos longer than 2 mm was 100 percent. However, the proportion of conversion into complete plantlets was somewhat less because of subsequent callusing of the embryoid or the formation of abnormal plantlets. The conversion rate of somatic embryos of different sizes into complete plantlets was as high as 85 % (Table 1).

Embryo morphology could have affected subsequent germination and conversion of somatic embryos into plantlets. Abnormal embryoids are common in other species, for example, caraway (Ammirato, 1974) and soybeans (Buchheim et al, 1989). Achieving a high degree of normal morphology usually involves optimizing the medium components and physical environment of the cultures.

The development of somatic embryos from REL-1 callus resulted in torpedo and cotyledonary embryoids. Although somatic embryogeny is reported to mimic zygotic embryogeny in many respects (Crouch, 1982; Sharp et al, 1980), this has yet to be demonstrated completely in sugarbeet. Artschwager (1927) and Artschwager and Starrett (1933) have described the anatomy of embryo and seed development in sugarbeet. A more detailed comparison of somatic with zygotic embryogenesis would require detection of earlier stages of somatic embryogeny in callus or liquid cultures.

Based on the research reported here, the model biotech clone REL-1 is capable of at least moderate intensities of somatic embryo production, which then are easily converted into plantlets. In order for REL-1 embryoids to be useful in gene transfer research, conditions for secondary embryoid production must be developed. If somatic embryos are to find a direct application in the field, conditions for their massive proliferation in other genotypes must be found. It is encouraging to note that both Tenning et al. (1992) and Kubalakova (1990) reported some secondary embryogenesis in sugarbeet cultures.

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Figures

Fig. 1A: The number of somatic embryos per ml of suspension plated onto media with combinations of BA and NAA 68 days after plate out. Means marked with same letter are not significantly different according to LSD with p < 0.05.

Fig. 1B: The number of somatic embryos per ml of suspension plated out onto media with combinations of ABA, NAA, and TIBA 33 days after plate out. Means marked with same letter are not significantly different according to LSD with p < 0.05.

Fig. 2A: Opaque white somatic embryos (1.5 mm long) on the surface of callus tissue 22 days after suspension plating.

Fig. 2B: A 3 mm long tricotyledonary somatic embryo 30 days after suspension plateout.

Fig. 2C: Isolated somatic embryos (length : 0.5 - 4 mm).

Fig. 2D: Somatic embryo-derived complete plantlet, 10 days after being transferred to hormone-free MS medium (length : 20 mm).

Table 1 : Effect of size on the proportions of somatic embryos germinating and converting into complete plantlets,

Length of somatic embryos mm	Germination rate %	Conversion rate %
(0.5 - 1.9)	88 (61/69)	78 (54/69)
(2.0 - 2.9)	100 (96/96)	81 (78/96)
(3.0 - 3.9)	100 (28/28)	86 (24/28)

Figure 1A

Number of somatic embryos per 1 ml of suspension plating-out (per plate) - after 68 days

Figure 1B

Number of somatic embryos per 1 ml of suspension plated out (per plate)
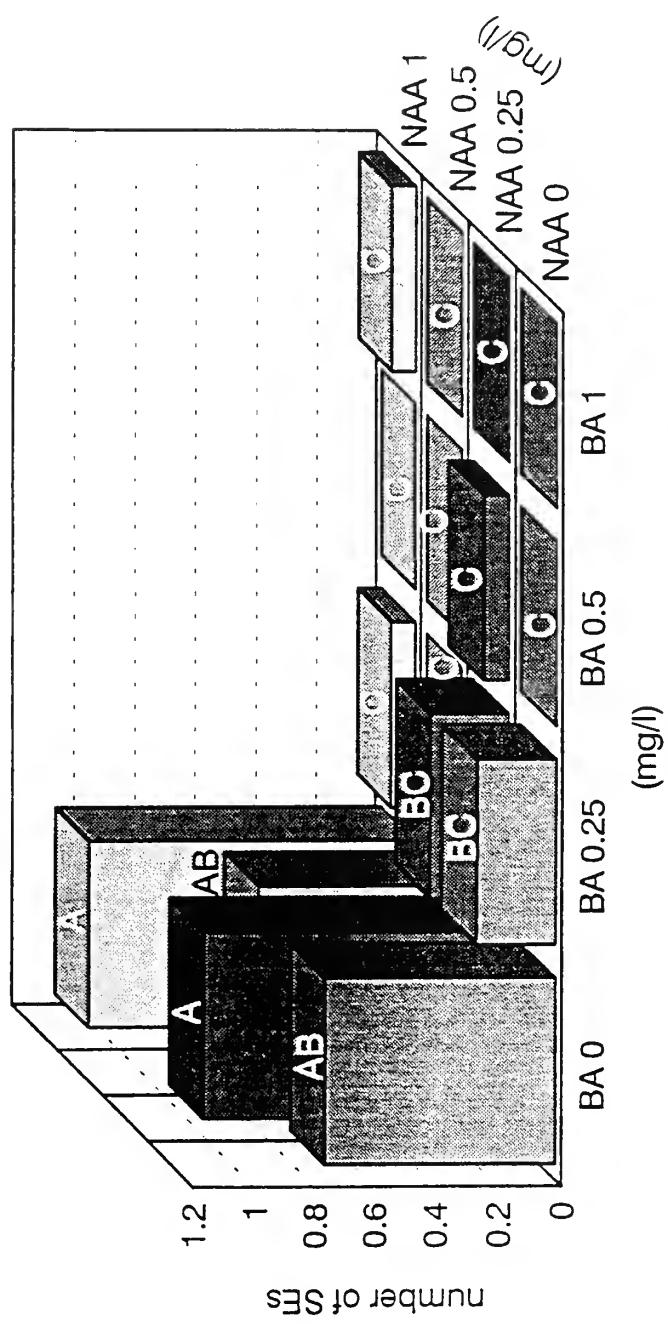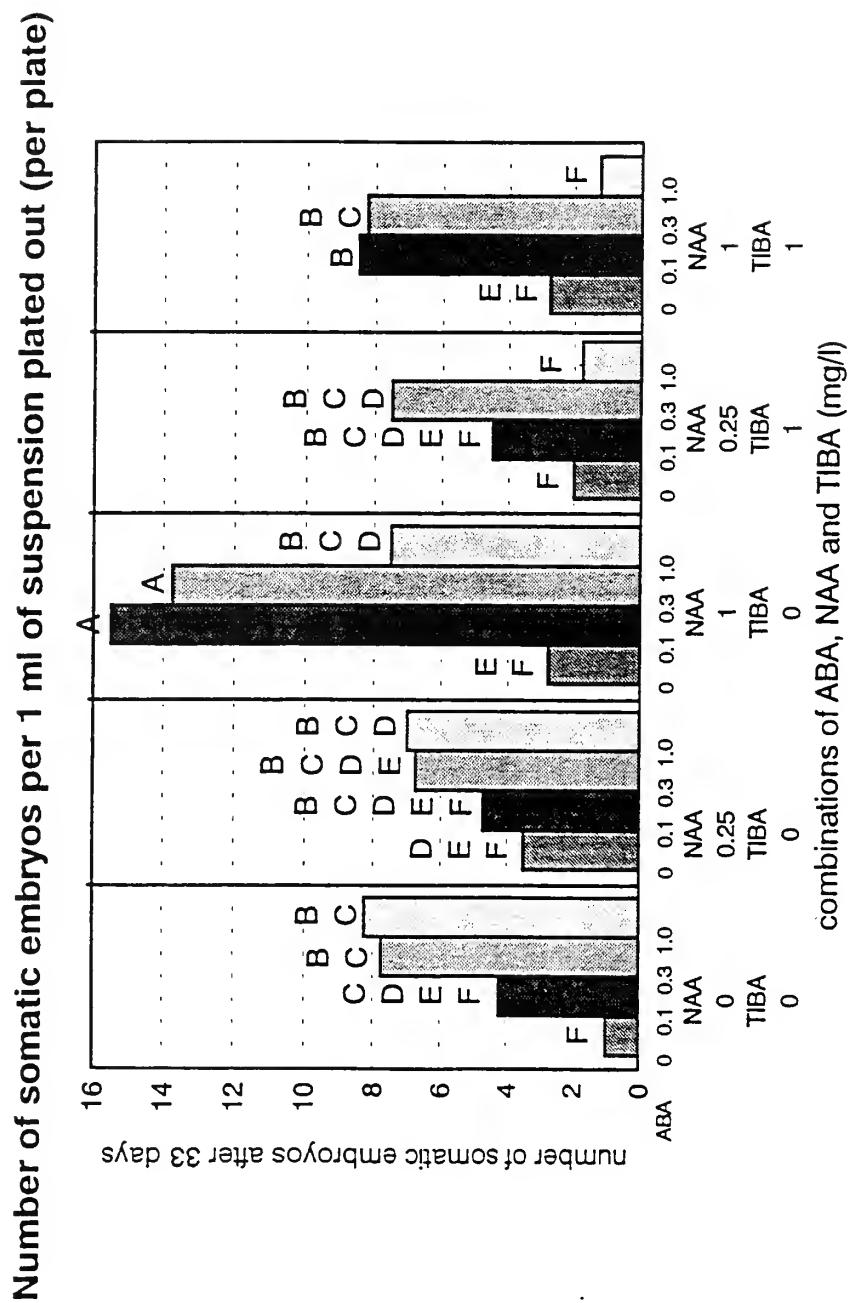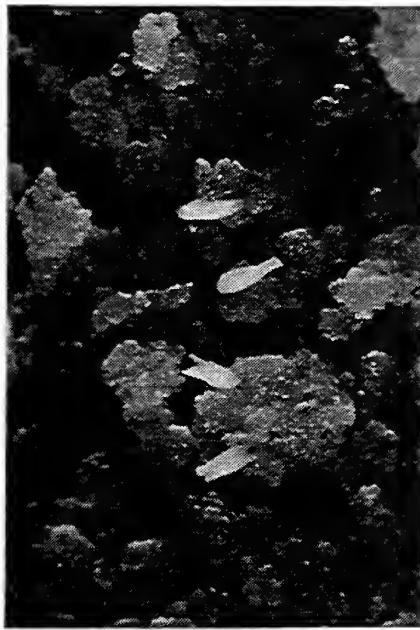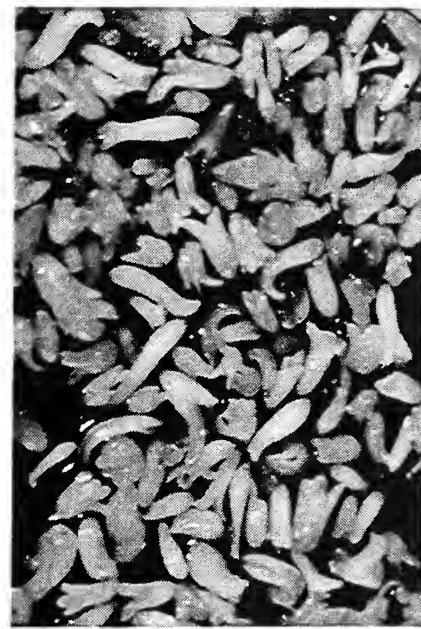
Figure 2B

Figure 2D

Figure 2A

Figure 2C

E18a

EVALUATION OF SUGARBEET SMOOTH ROOT BREEDING LINES AND EXPERIMENTAL HYBRIDS - 1994

J. C. Theurer

In 1994 we continued our selection program to enhance the sucrose content of smooth root (SR) genotypes and to develop disease resistant SR germplasm. Selections, experimental hybrids, and SR populations were also evaluated for their agronomic performance. Over 10,000 plants were grown in our SR nursery in 1994 and 959 individual plants having excellent smoothness of root were analyzed for sucrose. Roots having sucrose percentage above that of the check cultivar ACH 185 were selected for seed increase during the winter of 1994-95 for the next selection cycle.

AGRONOMIC EVALUATION OF PROGENIES DERIVED FROM 1993 INDIVIDUAL SR BEET SELECTIONS WITH HIGH SUCROSE PERCENTAGE.

This experiment was designed to evaluate seasonal sucrose accumulation and the agronomic performance of a group of high sucrose SR progenies. Individual beets with good SR shape and high sucrose percentage on a fresh weight basis ranging from 100-112% of that for ACH 185 had been selected from the 1993 SR breeding nursery. Seed was produced in groups with 3-10 roots in each group, depending upon the pedigree of the breeding material. Sufficient quantities of seed were obtained to evaluate 18 progenies in a replicated field trial. The 18 SR progenies plus ACH 185 and ACH 197 commercial hybrid checks were planted in two row plots with rows 28 inches apart and 30 feet in length in a 6 replicate field trial. Just prior to harvest the length of each plot row was measured and adjustments made to correct for areas in the row where skips occurred and to determine the plot area. All roots were machine harvested for root weight and a 15 beet sample from each plot was used for determining sucrose and CJP percentages. Sucrose and CJP were determined by Michigan Sugar Company personnel in their research laboratory at Carrollton, MI using standard thin juice methods. A root smoothness score was estimated for each plot by observing the beets as they fell into the weighing basket. Entries were scored on a 1-5 scale as defined below:

1 = Very smooth taproot, no grooves, broad fibrous root zone
2 = Smooth, slightly grooved taproot, narrow fibrous root zone
3 = Partially smooth, grooved, heavy fibrous non-branching taproot
4 = Rough shaped taproot, deep grooves, heavy fibrous roots with some sprangling
5 = Very rough, very deep grooves, multiple branched taproot

Data was analyzed using the Michigan State University MSTAT statistical program.

RESULTS

Sugar production of the SR lines in this experiment ranged from 82% to 112% of ACH185 . SR line 94HS21 had the highest recoverable white sugar per acre (RWSA) and all but four (94HS15, 94HS24, 94HS7 and 94HS1) of the SR selections had equal RWSA to that of the two commercial check cultivars (Table 1). Sugar yields were not correlated with the sugar percentage levels of the SR plants used to produce the seed of the respective lines. The commercial varieties had the highest recoverable white sugar per ton (RWST), however, four SR lines were not significantly lower than the checks in RWST. Root yield of the SR lines ranged from 84% to 116% of ACH 185. Eight of the SR lines were higher in root yield and 10 were lower than ACH 185. However, yield differences were significant for only the highest (94HS21) and the Lowest (94HS1) yielding SR lines. The sucrose percentages for the SR lines ranged from 17.91% to 19.23%. The commercial cultivars were highest in sucrose percentage, but two SR lines (94HS15 and 94HS4) were not significantly lower than the checks for this character.

There wasn't a good correlation with the mean sugar percentage of plants used in seed production for each SR line and the sucrose percentage realized in the replicated field trial. The SR line with highest sugar percentage (94HS15) was developed from plants averaging 104% of the sucrose percentage of ACH 185. The next two highest sugar lines (94HS4, and 94HS3) were derived from parentage averaging 112% of ACH 185. These would be expected to have the highest sucrose content. SR lines with the lowest sugar percentage, 94HS7 and 94HS9, were from seed of plants averaging 106% sucrose of ACH 185. One of the lines developed from plants averaging 103% (94HS21) had a sucrose percentage that was not significantly different from 94HS3 with parentage of 112%.

These results suggest that we need to select for as high sucrose percentage as possible, when we select individual plants for seed production , but we can only measure our progress of incorporating high sucrose into SR material by progeny testing. Two SR progenies had significantly higher clear juice purity (CJP), otherwise there was no difference with the CJP of SR lines and ACH 185. All SR lines had significantly better smooth root scores than the commercial check varieties. Line 94HS9 had significantly higher smoothness score than other SR lines. SR lines having the highest sucrose percentage (94HS15, 94HS3 and 94HS4) were among the SR lines having the lowest smoothness score. Lines 94HS10, 94HS25, and 94HS5 were the best lines overall for high root yield, high sucrose percent, and smoothness of root. Further selection and breeding should be done with these lines and also with the high sucrose percentage SR lines 94HS1 and 94HS15.

EVALUATION OF THE COMBINING ABILITY OF AN SR LINE FROM 85131-14 AND A LINE DERIVED FROM C40 HIGH SUGAR INBRED X 85131-14.

SR 85131-14 was a multigerm line received from Dr. G.E. Coe that had high root yield and looked promising for selection. SR sister lines 91HS10, and 91HS11, selected from 85131-14, and line 92HS25, selected from the cross C40 x 85131-14 were crossed with five CMS lines in 1992 and 1993 respectively, in Oregon seed

increase plots. The ten hybrids and the parent inbred lines were planted in 1994 with ACH 185 and MH E-4 commercial cultivars at the B&B Farm in six replications of a randomized block design for assessing their combining ability. Individual plots were two rows 28 inches apart and 30 feet in length. At harvest, plot row lengths were measured to adjust plot size. Root yield, smoothness of root score and laboratory determinations for sucrose percentage and CJP were made similar to that outlined in the section above.

RESULTS

Mean sugar yield, root yield, sucrose percentage, clear juice percentage and root smoothness scores are given in Table 2. Two hybrids (USH23 CMS x 91HS10,11 and FC607 CMS x 92HS25) had slightly higher RWSA than MH E-4. One experimental hybrid was significantly lower in RWSA than the check, and all others had similar sugar yield. ACH 185 was unexpectedly among the entries with the lowest RWSA. The two check varieties had the highest RWST. Although the mean RWST for the experimental hybrids was lower than the checks, differences were not statistically significant. The inbred smooth root lines (92HS25, 91HS10 AND 91HS11) had the lowest RWST, over 22.5 pounds per ton lower than the checks. Hybrid USH23 CMS x 91HS10,11 had significantly the highest root yield. The tonnage per acre for most other hybrids and inbred lines was similar to that of MH E-4. ACH 185 root yield was lower than expected, but we have no reasons to explain why this occurred.

ACH 185 was significantly better in sucrose percentage than all other entries in the test. Two hybrids (567 Cms x 92HS25 and 576 x 91HS10,11 had sucrose percentage equal to the MH E-4 check. The other hybrids and the inbred lines ranged from 0.7 to 1.6 percent lower sugar than MH E-4, and 1.3 to 2.3 percent lower than ACH 185. There was very little difference among the entries in CJP. As expected the four smooth root inbred entries (91HS10, 91HS11, 91HS10,11 mix and 92HS25) were lowest in root smoothness score. All experimental hybrids had significantly lower smoothness scores than the check varieties. The greatest disappointment in the test was the observation that three of the hybrids with 92HS25 parentage had relatively poor smoothness scores. SR line 92HS25 itself had shown rather uniform excellent smooth roots in a 1993 observation nursery at East Lansing.

EVALUATION OF SR LEAFSPOT RESISTANT SELECTIONS, AND SR LINES WITH THE Sur GENE.

This experiment originally consisted of 14 entries planted in 6 replications of plots 28 inches between rows and 30 feet in length. However, four of the entries, from crosses made with commercial cultivars and SR-chlorosulfuron lines had no emergence. The seed was from 2N X 3N crosses and probably had no viable embryos, but looked plump due to parthenocarpy of the corky growth of fruit of the female seed parent. Since the plants would essentially be triploid in such crosses, it was not too much of a surprise that very few seedlings emerged. The other entries included seven crosses of individual plants of SR80 or SR87 x the

recently released leafspot resistant line EL50, one Sur line and a related SR sulfonylurea susceptible line (Sur lines = SR X Sulfonylurea herbicide resistant line) and the ACH 185 commercial check. ACH 197 commercial variety was seeded about June 7 in all plot rows where germination had not occurred to provide plant competition for the remaining plots. The experiment was harvested and laboratory analyses were made using the same methods as stated in a previous section of this report.

RESULTS

Observation of root weights indicate that plots with a border row that was planted late were about 10% higher than for plots with border rows of the original planting date. Thus the plot root yield was reduced 10% for each plot with a late planted border row. Sugar yield, root yield, sugar percentage, CJP percentage and smoothness scores for these entries are given in Table 3. RWSA of all entries except the Sur homozygote line 94494 was similar to the ACH 185 commercial check variety. All entries were 12% to 18% lower in RWST than ACH 185. This was due to the 2.4% to 3.1% lower sucrose percentage of the SR material compared to ACH 185. All but one line had higher root weight than ACH 185, and the differences for three of the entries (94H1, 94H4 and 94H6) were statistically significant. Entries highest in sucrose percentage were also the lowest in root yield and vice versa. There was very little difference between entries in CJP. Highly significant differences were noted among entries for smoothness of root score. The check variety had the highest (Least smooth) score and the sur line 93293 had the smoothest roots.

Table 1. Sugar yield, Root yield, Sucrose %, Clear juice purity %, and smoothness score, for smooth root lines. Saginaw, MI. 1994.

Variety/Line	Sugar Yield RWSA #		Root Wt. RWST #		T/AC		Suc %		CJP %		SR Score	
ACH 185	6499	ABCDE*	281.3	AB	23.08	BCDE	19.45	A	93.71	ABC	3.450	A
ACH 197	6822	ABC	282.3	A	24.20	ABCD	19.25	AB	94.40	AB	3.450	A
94HS1	5320	G	274.0	ABCD	19.42	F	18.90	BCD	93.93	ABC	2.650	C
94HS5	6365	BCDEF	278.0	ABC	22.95	BCDE	19.04	ABC	94.22	AB	2.500	CDEF
94HS6	5759	EFG	270.8	CD	21.27	DEF	18.69	CDE	93.94	ABC	2.400	CDEFGH
94HS7	5527	FG	259.2	G	21.34	DEF	18.01	GH	93.75	ABC	2.517	CDEF
94HS9	5947	CDEFG	259.6	FG	22.90	BCDE	17.91	H	94.09	AB	3.067	B
94HS10	6792	ABC	272.6	BCD	24.89	ABC	18.84	BCD	93.84	ABC	2.317	DEFGHI
94HS11	7043	AB	269.8	CDE	26.13	AB	18.49	DEF	94.30	AB	2.167	HI
94HS13	5836	DEFG	260.9	EFG	22.40	CDEF	18.28	EFGH	93.35	BC	2.067	I
94HS15	5551	FG	273.4	ABCD	20.32	EF	19.23	AB	93.00	C	2.533	CDE
94HS16	6403	ABCDEF	265.0	DEFG	24.16	ABCD	18.20	FGH	94.26	AB	2.650	C
94HS17	6209	BCDEFG	269.3	CDEF	23.06	BCDE	18.58	DEF	93.97	ABC	2.233	EDFGHI
94HS18	6856	ABC	267.4	DEFG	25.62	ABC	18.37	EFG	94.21	AB	2.217	FGHI
94HS19	6142	BCDEFG	268.9	CDEF	22.84	BCDE	18.36	EFG	94.51	A	2.100	HI
94HS21	7288	A	271.5	CD	26.84	A	18.56	DEF	94.40	AB	2.183	GHI
94HS22	6695	ABCD	265.5	DEFG	25.25	ABC	18.17	FGH	94.40	AB	2.083	HI
94HS24	5535	FG	269.2	CDEF	20.56	EF	18.34	EFGH	94.60	A	2.483	CDEFG
94HS25	6530	ABCDE	268.9	CDEF	24.23	ABCD	18.68	CDE	93.63	ABC	2.183	GHI
94HS20	6488	ABCDE	268.9	CDEF	24.10	ABCD	18.46	DEF	94.23	AB	2.567	CD
Mean	6280		269.8		23.28		18.59		94.04		2.49	

*Duncan's Multiple Range Test - Means with same letter suffix are not significantly different at the 0.05 level.

E23

Table 2. Sugar yield, Root yield, Sucrose %, and Clear juice purity %, and smoothness score, for smooth root experimental hybrids. Saginaw, MI. 1994.

Variety/Line	Sugar Yield		Root Wt.	Suc %		CJP %		SR Score	
	RWSA #	RWST #	T/AC						
ACH 185	5961 CD*	279.0 A	21.37 E	19.34	A	93.62	AB	3.417	A
MH E4	6750 AB	272.7 AB	24.75 BC	18.66	B	94.35	AB	3.417	A
USH 23 X 91HS10,11	7096 A	257.2 BCD	27.57 A	17.76	CD	94.08	AB	2.567	CDEFG
657 CMS X "	6307 BC	255.6 BCD	24.69 BC	17.59	CDE	94.28	AB	2.600	BCDEF
567 CMS X "	6264 BC	259.0 ABCD	24.22 BCD	18.07	BC	93.58	AB	2.617	BCDEF
FC607 CMS X "	6517 ABC	258.7 ABCD	25.21 BC	17.71	CD	94.47	AB	2.417	DEFGH
BMC CMS X "	6526 ABC	262.5 ABCD	24.85 BC	17.91	CD	94.62	AB	3.000	B
USH 23 X 92S25	6481 ABC	256.7 BCD	25.25 BC	17.56	CDE	94.56	AB	2.583	BCDEFG
657 CMS X "	5987 CD	255.0 BCD	23.46 CDE	17.55	CDE	94.27	AB	2.317	EFGH
567 CMS X "	6396 ABC	266.8 ABC	24.01 BCD	18.16	BC	94.68	AB	2.783	BCD
FC607 CMS X "	6771 AB	260.7 ABCD	25.98 AB	17.78	CD	94.66	AB	2.733	BCDE
BMC CMS X "	6284 BC	268.7 ABC	23.51 BCDE	17.97	CD	95.88	A	2.900	BC
91HS10	5873 CD	248.5 CD	23.64 BCDE	17.03	E	94.62	AB	2.267	FGH
91HS11	6221 BC	250.2 CD	24.85 BC	17.32	DE	94.06	AB	2.117	H
91HS10,11 MIX	6141 BC	257.5 BCD	23.86 BCD	17.63	CDE	94.48	AB	2.133	H
92HS25	5328 D	241.5 D	22.04 DE	17.66	CDE	92.12	B	2.167	GH
Mean	6306	259.4	24.33	17.85		94.27		2.63	

* Duncan's Multiple Range Test - Means with same letter suffix are not significantly different at the 0.05 level

E24

Table 3. Sugar yield, Root yield, Sucrose %, Clear juice purity %, and Smoothness score for smooth root experimental crosses. Saginaw, MI. 1994.

Variety/Line	Sugar Yield				Root Wt.		Suc %		CJP %		SR Score	
	RWSA #		RWST #		T/AC							
ACH 185	6520	AB*	282.3	A	23.12	D	19.59	A	93.55	ABC	3.500	A
93293	6539	AB	247.2	BC	26.48	ABCD	17.18	B	93.90	ABC	1.583	F
94494	5363	C	232.0	D	23.12	D	16.43	C	91.18	C	2.033	E
94H1	6899	A	237.3	CD	29.21	A	16.74	BC	93.28	BC	2.600	C
94H2	6193	AB	245.6	BC	25.20	BCD	17.07	B	93.91	ABC	2.950	B
94H3	6430	AB	245.7	BC	26.18	ABCD	16.85	BC	94.57	AB	2.267	D
94H4	6727	AB	241.2	BCD	27.89	AB	16.84	BC	93.77	ABC	2.633	C
94H5	6251	AB	250.1	B	25.03	BCD	17.08	B	94.72	A	2.600	C
94H6	6624	AB	245.7	BC	26.99	ABC	16.93	BC	94.36	ABC	2.633	C
94H7	5976	BC	250.0	B	23.92	CD	17.20	B	94.36	ABC	2.600	C
Mean	6352		247.7		25.71		17.19		93.96		2.54	

*Duncan's Multiple Range Test - Means with same letter suffix are not significantly different at the 0.05 level.

E25

1994 EXPERIMENTS TO EVALUATE DIVERSE GENOTYPES FOR POTENTIAL NITROGEN USE EFFICIENCY.

J. C. Theurer and J. W. Saunders

Nitrogen fertilization is an important aspect for growing a good sugarbeet crop. Sufficient N is required for the beet to make rapid growth in the spring and to quickly develop a canopy of leaves for photosynthesis, for further plant growth, and for sucrose accumulation. Excess N at harvest results in higher impurities in the root and more difficulty in processing to sugar. Also, in recent years the public has expressed considerable concern regarding the quantity of nitrogenous and other chemical residuals in soils and water.

In 1990 a research program was initiated to evaluate diverse genotypes for their potential difference in tolerance to high N or their efficiency for high sugar production with low nitrogen availability. Minor differences in N response were noted for some genotypes in past years.

In 1994 we continued this research by evaluating the response of another group of highly diverse genotypes to differential nitrogen fertilization treatments. Fifteen highly diverse genotypes (Table 1) of sugarbeet including high sugar lines selected by ARS personnel at Fargo, ND along with the check variety ACH 185, were planted on May 6, 1994 in a randomized block experiment of four replications at the Bean and Beet Research Farm near Saginaw, MI. Individual plots were two rows 28" apart and 30' in length. Adequate phosphorus and potassium fertilizer was applied pre-plant but no N fertilizer was applied until after thinning. In mid-July the plots were fertilized with zero, 90# (optimum nitrogen fertilization for Michigan) or 180# ammonium nitrate/acre in accordance with the randomized block field plan.

The experiment was machine harvested on October 6, 1994. The row length of each plot was measured just prior to harvest to adjust plot size for any skips within the rows. All roots in each plot were weighed to determine root yield and recoverable white sugar per acre (RWSA). A fifteen beet random sample of roots was taken from each plot to determine sucrose percentage, Clear juice purity percentage (CJP) and meq amino N per 100 g. sugar. These determinations were made by Michigan Sugar Company personnel at their research lab in Carrollton, MI. Data was summarized and analyzed using the MSTAT statistical program developed at Michigan State University.

RESULTS

Two entries (F1011, a high sugar selection from Polish material and EL 6926-0 inbred) had very poor stands in all plots. Data from these two entries were not included in the statistical analyses. Means for sugar yield, root yield, sucrose percent, CJP, and meq. amino N/100 grams of sugar are given in Table 2. Summed over varieties, the three fertilizer levels showed similar response as observed in previous years. As the quantity of N fertilizer is increased, the RWSA, Tons/Acre beet roots and amino N in the root increases, while RWST, sucrose percent and CJP decreases.

Means of varieties summed over fertilizer levels shows highly significant differences for all characteristics measured (Table 3). ACH 185 commercial variety check had the highest RWSA and A93-4, a 4 cycle selection from L53 x Beta maritima, had the lowest RWSA. L19/2 had the highest sucrose percentage and RWST, followed by ACH 185. A93-9, a high crown selection from a world collection of Beta, and A93-4 were lowest among the entries for these characteristics. As expected the high sugar entries had high sugar percentages and lines known to be yield types were on the low end for sucrose percentage. This was reversed for mean root yield where the sugar types showed lower yield. The EL 45/2 inbred and A93-4 had significantly the lowest tonnage among the entries. Two entries, A93-9 and A93-6 had significantly the highest root yield. There was no significant difference between 10 of the fourteen entries for CJP. A93-9, F1012, and A93-4 had very low CJP compared to the other entries.

No relationship was observed between sucrose percentage and the quantity of Amino N in the root at harvest. High sugar and high yield lines were interspersed from the highest to the lowest amounts. An East Lansing high sugar composite had the lowest Amino N and A93-4 had the highest. In most cases the N_1 level (zero applied N) had significantly lower RWSA than N_2 (90# N) and N_3 180# N and N_2 was usually equal to that of the RWSA of the N_3 level (Table 4). For four entries (L19/2, A93-4, F1013, and 88B24-02) the N_3 level significantly exceeded the RWSA of that of the N_2 level. RWSA for 84B9-24-02 showed N_1 equal to N_2, N_2 equal to N_3 but N_3 significantly higher than N_1. Eleven of the entries had significantly lower RWST with N_3 than with N_2. Most of the entries also showed an RWST for N_2 that was not significantly lower than that observed at the N_1 level. The RWST for A93-9 and F1014 at the N_1 level was significantly lower than for N_2. The RWST for F1012, 91S3-00 and 84B9-24-02 at N_3 was no different than for N_2 but the N_1 level was significantly higher in RWST than N_3. Line 88B24-02 showed step-wise significance in that RWST was higher for N_1 than N_2 and N_2 was higher than N_3.

The root yield of all entries was significantly lower at the N_1 level than at the other two N levels. Five entries (L19/2, A93-4, F1012, F1013, and 88B24-02 showed significantly higher root yield at N_3 than at N_2. For nine of the 14 entries, sucrose percentage of N_1 was similar to that of N_2 and significantly higher than for N_3. Line A93-9 had significantly higher sucrose percentage for N_2 versus N_3, and N_1 level was significantly higher than N_2. Three lines, F1012, F1013, and 91S3-00 showed similar sucrose percentage at the N_2 and N_3 levels with significantly higher sucrose percentage at the N_1 level. For line 84B9-24-02, sucrose percentage at N_1 was equal to that of N_2, N_2 was equal to that of N_3 and N_1 was significantly higher than for N_3 level.

There were very few differences between nitrogen levels for CJP. Four lines (A93-4, A93-9, F1014 and 84B-24-02) showed significantly less CJP at the N_3 level than at N_1. The N_1 level gave better CJP for line EL 45/2 than at either N_2 or N_3. Four entries (ACH 185, F1012, EL 48, and 84B9-24-02) showed significantly higher meq amino N/ 100 grams sugar at the N_3 level versus N_1, and for three lines (L19/2, 91B1-00 and 88B24-02), N_3 was significantly higher than at

either N_1 or N_2. For four lines (A93-4, A93-6, A93-9, and F1013), the meq amino N/100 grams of sugar was significantly higher at the N_3 than at N_2 level, and higher at N_2 than at N_1. Lines F1014 and El 45/2 showed N_1 significantly lower than N_2 and N_2 similar to N_3 for this characteristic. Line 91S3-00 had similar meq amino N/100 grams sucrose at all three N levels.

DISCUSSION

There were two alternatives or selection schemes planned in our original premise to search for genotypes with greater nitrogen use efficiency: 1) genotypes that could metabolize an excess of nitrogen fertilizer without decreasing the sucrose content or increasing the amino N and other impurities in the sugarbeet root at harvest; and 2) genotypes that could produce a satisfactory root and sugar yield with a limited quantity of nitrogen.

The 1994 test was similar to that of previous years in that none of the genotypes tested showed any indication of an increased nitrogen efficiency because of their ability to utilize an excessive amount of nitrogen. In previous years we have observed a few lines which were able to produce about as much sugar and root yield under zero applied nitrogen (with only the residual soil nitrogen from a previous crop) as with the 90# N optimum fertilization recommended for a sugarbeet crop grown in Michigan. This year only one genotype showed any possible potential for nitrogen use efficiency under zero fertilization. 84B9-24-02 produced 5357 pounds of RWSA which was not statistically significantly different from the 5932 pounds of RWSA realized with the 90#/Acre fertilization. Overall the results indicate that selection and development of a sugarbeet with nitrogen use efficiency could be a difficult task.

Table 1. Description of genotypes used in Nitrogen efficiency study.

	Genotype	Description
1.	ACH 185	Commercial Hybrid
2.	L19/2	L19 Selection
3.	A93-4	4CYL L53X B.maritima
4.	A93-6	M140 Mix SB Lines
5.	A93-9	Hi Crown - World Col
6.	F1012	Hi Sugar Sel. Poland
7.	F1013	Hi Sugar Sel. Turkey
8.	F1014	Hi Sugar Sel. Russia
9.	91S3-00	EL Hi Sugar Composite
10.	82B10-00	EL 48 Inbred
11.	WC86054	EL 45/2 Inbred
12.	WC90613	84B9-24-02 EL High yield
13.	91B1-00	85300-193 COE BRR-LSR
14.	88B24-02	EL Clones x L19

Table 2. Means for N level summed across varieties for sugar yield, root yield, sucrose percentage, clear juice purity percentage, and meq amino N/100 g. sugar. B&B Farm. 1994.

N Level # Acre	Sugar Yield RWSA #	RWST #	Root Wt. T/A	Suc %	CJP %	Amino N meq/100 g sug.
0	4782 C*	256.4 A	18.66 C	17.84 A	93.72 A	7.780 C
90	6181 B	248.6 B	24.96 B	17.53 B	93.14 B	11.35 B
180	6417 A	234.2 C	27.58 A	16.82 C	92.47 C	15.33 A
Mean	5793	246.4	23.73	17.40	93.11	11.48

*Duncan's Multiple Range Test - Means with same letter suffix are not significantly different at the 0.05 level.

Table 3. Means for varieties summed across N Levels, sugar yield, root yield, sucrose percentage, clear juice purity percentage, and meq amino N/100 g. sugar. B&B Farm. 1994.

| Variety | Sugar Yield | | Root Wt. | Suc % | CJP % | Amino N |
	RWSA #	RWST #	T/A			meq/100 g suc.
ACH 185	7035 A*	271.7 B	25.91 CD	19.04 B	93.20 AB	8.390 EFG
L19/2	5773 DE	280.3 A	20.69 H	19.87 A	92.55 BC	11.51 D
A93-4	3461 G	216.1 I	16.14 I	15.75 H	92.11 C	21.98 A
A93-6	6795 AB	245.2 FG	27.84 B	17.31 E	93.17 AB	12.66 D
A93-9	5951 D	189.3 J	31.83 A	14.23 I	91.17 D	16.91 B
F1012	5756 DE	263.3 C	21.99 FGH	18.20 C	93.94 A	8.367 EFG
F1013	5413 E	244.8 FG	22.34 FG	17.70 D	92.05 C	15.28 C
F1014	5462 E	258.5 CD	21.26 GH	18.11 C	93.34 AB	9.275 EF
91S3-00	6413 BC	260.2 CD	24.71 DE	18.23 C	93.32 AB	7.342 G
82B10-00	6133 CD	234.3 H	26.25 C	16.47 G	93.52 A	9.477 EF
WC86054	4011 F	240.1 GH	16.87 I	16.84 F	93.52 A	12.50 D
WC90613	5808 DE	249.6 EF	23.31 EF	17.30 E	94.01 A	7.924 FG
91B1-00	6452 BC	241.7 G	26.81 BC	16.87 F	93.75 A	9.855 E
88B24-02	6645 AB	254.7 DE	26.30 C	17.66 D	93.89 A	9.304 EF
Mean	5793	246.4	23.73	17.40	93.11	11.48

*Duncan's Multiple Range Test – Means with same letter suffix are not significantly different at the 0.05 level.

Table 4. Sugar yield, root yield, sucrose percentage, clear juice purity percentage, and meq amino N/100 g. sugar for diverse sugarbeet genotypes grown under three N environments. B&B Farm. 1994.

Variety	RWSA #		RWST #		Tons/ acre		Level N #/A
ACH 185	5847	JKL*	274.1	BC	21.35	MNOP	0
	7760	A	278.3	AB	27.89	EFGHI	90
	7498	AB	262.8	CDEF	28.51	CDEFG	180
L19/2	4195	O	282.7	AB	14.88	TU	0
	6097	GHIJKL	287.9	A	21.18	MNOP	90
	7027	ABCDE	270.2	BCD	26.00	GHIJ	180
A93-4	2264	P	221.9	N	12.02	V	0
	3329	P	219.0	N	15.18	TU	90
	4389	O	207.4	O	21.22	MNOP	180
A93-6	5921	IJKL	256.5	EFGHI	23.09	KLMN	0
	7390	ABCD	249.2	FGHIJK	29.64	CDEF	90
	7074	ABCDE	230.0	LMN	30.79	CD	180
A93-9	4537	O	202.9	0	22.36	MNO	0
	6508	EFGHIJ	188.2	P	34.58	B	90
	6810	BCDEFG	176.6	Q	38.55	A	180
F1012	4823	MNO	275.1	BC	17.53	QRST	0
	5953	HIJKL	263.5	CDE	22.60	LMNO	90
	6490	EFGHIJ	251.3	EFGHIJK	25.85	GHIJK	180
F1013	4299	O	258.0	DEFGH	16.68	RST	0
	5486	KLM	246.6	GHIJK	22.23	MNO	90
	6454	EFGHIJ	229.7	LMN	28.10	DEFGH	180
F1014	4530	O	273.0	BC	16.58	ST	0
	6092	GHIJKL	259.3	DEFG	23.51	JKLMN	90
	5763	JKL	243.1	IJK	23.69	JKLM	180
91S3-00	5728	JKL	271.0	BCD	21.15	MNOP	0
	6658	DEFGHI	259.5	DEFG	25.65	HIJK	90
	6852	BCDEFG	250.2	EFGHIJK	27.35	FGHI	180

Table 4.   Continued.

Variety	RWSA #		RWST #		Tons/ acre		Level N #/A
EL48	4749	NO	240.0	JKL	19.79	OPQ	0
	7012	ABCDE	240.8	JKL	29.11	CDEF	90
	6638	DEFGHI	222.2	N	29.86	CDEF	180
EL 45/2	3225	P	253.3	EFGHIJ	12.74	UV	0
	4461	O	240.9	JKL	18.55	PQRS	90
	4348	O	226.0	MN	19.32	PQR	180
84B9-24-02	5357	LMN	259.3	DEFG	20.69	NOP	0
	5932	IJKL	246.3	GHIJK	24.00	JKLM	90
	6136	FGHIJK	243.3	IJK	25.23	IJKL	180
91B1-00	5318	LMN	252.4	EFGHIJ	21.07	MNOP	0
	7137	ABCDE	245.1	HIJK	29.11	CDEF	90
	6901	BCDEF	227.7	LMN	30.27	CDE	180
88B24-02	5753	JKL	269.9	BCD	21.30	MNOP	0
	6719	CDEFGH	256.2	EFGHI	26.23	GHIJ	90
	7463	ABC	238.0	KLM	31.36	C	180
MEAN	5793		246.4		23.73		

Variety	Sucrose %		CJP %		Amino N meq/100 g suc.		Level N #/A
ACH 185	19.36	B	92.79	DEFGHI	6.934	LMNO	0
	19.32	B	93.57	ABCDEFG	7.832	JKLMNO	90
	18.43	CD	93.25	BCDEFGHI	10.40	GHIJK	180
L19/2	20.12	A	92.38	GHIJK	8.873	JKLMN	0
	20.26	A	92.82	DEFGHI	10.23	GHIJKL	90
	19.24	B	92.45	FGHIJ	15.44	CDE	180

Table 4. Continued

Variety	Sucrose %		CJP %		Amino N meq/100 g suc.		Level N #/A
A93-4	15.74	TU	93.28	BCDEFGHI	14.86	CDE	0
	16.04	ST	91.86	IJK	22.71	B	90
	15.47	U	91.20	JKL	28.37	A	180
A93-6	17.80	EFGHI	93.83	ABCDEFG	9.162	IJKLMN	0
	17.60	HIJK	93.09	CDEFGHI	12.65	EFGH	90
	16.52	PQRS	92.59	EFGHIJ	16.17	CD	180
A93-9	14.93	V	91.93	HIJK	10.83	FGHIJ	0
	14.17	W	91.16	JKL	16.10	CD	90
	13.60	X	90.41	L	23.81	B	180
F1012	18.83	BC	94.28	ABCD	5.805	NO	0
	18.16	DEFGH	94.08	ABCDE	8.429	JKLMNO	90
	17.60	HIJK	93.45	ABCDEFGH	10.87	FGHIJ	180
F1013	18.29	CDE	92.79	DEFGHI	8.871	JKLMN	0
	17.69	FGHIJ	92.40	GHIJK	14.69	CDE	90
	17.12	JKLMNO	90.96	KL	22.28	B	180
F1014	18.58	CD	94.60	ABC	6.126	NO	0
	18.26	CDEF	93.09	CDEFGHI	10.52	GHIJK	90
	17.48	IJKL	92.33	GHIJK	11.18	FGHIJ	180
91S3-00	18.81	BC	93.65	ABCDEFG	5.864	NO	0
	18.20	DEFG	93.29	BCDEFGHI	7.180	KLMNO	90
	17.69	FGHIJ	93.01	DEFGHI	8.981	IJKLMN	180
EL48	16.68	OPQR	93.98	ABCDEF	6.523	MNO	0
	16.78	NOPQ	93.84	ABCDEFG	9.586	HIJKLM	90
	15.94	TU	92.74	DEFGHI	12.32	EFGHI	180
EL 45/2	17.29	IJKLMN	94.72	AB	6.419	MNO	0
	17.02	KLMNOP	93.16	CDEFGHI	14.05	CDEF	90
	16.20	RST	92.68	EFGHI	17.08	C	180

Table 4.   Continued

Variety	Sucrose %		CJP %		Amino N meq/100 g suc.		Level N #/A
84B9-24-02	17.66	GHIJ	94.74	AB	5.265	O	0
	17.19	JKLMNO	93.69	ABCDEFG	7.941	JKLMNO	90
	17.04	KLMNOP	93.59	ABCDEFG	10.57	GHIJK	180
91B1-00	17.39	IJKLM	94.26	ABCD	6.965	LMNO	0
	16.69	LMNOP	94.13	ABCDE	8.730	JKLMN	90
	16.26	QRST	92.86	DFGHI	13.87	CDEF	180
88B24-02	18.28	CDE	94.88	A	6.422	MNO	0
	17.82	EFGHI	93.72	ABCDEFG	8.198	JKLMNO	90
	16.87	MNOP	93.07	CDEFGHI	13.29	DEFG	180
MEAN	17.40		93.11		11.48		

*Duncan's Multiple Range Test - Means with same letter suffix are not
significantly different at the 0.05 level.

EVALUATION OF SUCROSE ACCUMULATION AND ANATOMY OF A GROUP OF HIGH SUCROSE GENOTYPES.

J.C. Theurer, R.C. Olien[1] and J. Clark[2]

Although considerable research has been done to study sucrose accumulation in sugarbeet, we still know very little about this important factor. However, we do know there are marked differences in sucrose accumulation among genotypes. The high sucrose inbred L19 has been shown to accumulate sucrose at a much faster rate than other high sugar genotypes (Theurer and Doney 1989). L19 also has shown marked differences from other lines in osmotic potential (Doney and Theurer 1990). Opportunity was taken this year to conduct a pilot study of sucrose accumulation in high sugar content genotypes utilizing techniques that Dr Olien had been using in studying carbohydrates at the cellular level in his research on cereal grain winterhardiness.

L19, four other high sugar inbreds, and the low sugar Ovana fodder beet were planted in a split plot randomized block experiment of 6 replications. Main plots were harvests (H) scheduled in mid-July, August, September and October. Fifteen beets were harvested from each plot for laboratory analyses each harvest date. Osmolality readings were made on a representative beet by a plug, crushed tissue, and frozen juice sample using tissue samples taken from the top of the beet and near the central vascular ring at each harvest. Anatomy readings were made of root diameter (at widest area), root length, number of vascular rings and width of the five center rings. Root volume was measured by water displacement and density determined by subjecting roots to different concentrations of salt solutions. Fresh weight of roots and tops was made. A sample of two tops was chopped, weighed, and dried in an 85°C oven to determine dry matter of tops. Two samples of brei were taken and dried, one to determine the total dry matter of the roots, and one to determine extracted insoluble dry the dry matter of the matter of the root. A sample of 11 beets was sawed for each genotype on each harvest date with a Spreckles 10 blade saw and 100 ml juice was collected and frozen for sucrose and CJP

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[1]USDA-ARS-Collaborator - Cereal Grain Physiologist

[2]Research Lab Technician

analyses which was done in the Michigan Sugar Lab. at Carrollton, MI. A 30 ml sample of juice was collected and frozen for HPLC studies at East Lansing.

RESULTS

Agronomic Evaluation:

The field planting sugar yield, root yield, sucrose percentage and clear juice purity percentage for the final harvest (H4) in October are given in Table 1. L19/2 and 576 genotypes were lower in root yield and RWSA than the other three genotypes. The 576 genotype was significantly lower in sucrose percentage and RWST than the four other genotypes. There was no significant difference in CJP. Means for sugar yield, root yield, sucrose percentage and CJP for genotypes summed over harvests, for harvests summed over genotypes, and for genotype x harvest interactions are given in Table 2. The RWSA, RWST, and Tons/acre were calculated on the basis of the weight of two representative beets for H1, H2, and H3 harvests and on a 15 beet sample for H4. Data for genotypes averaged over harvest was similar to that for the fourth harvest (see Table 1) except that L19/2 and C51 genotypes were significantly lower than the three other genotypes for CJP. As expected, sugar yield, root yield, and sucrose percentage showed significantly higher values with each harvest from H1 to H3. There was no difference in tonnage between H3 and H4. There was no difference in CJP beyond H2. Genotypes C51, C40, and F1010 consistently showed increased root yield, sugar percentage, and sugar yield from H1 to H4. L19/2 and 576 differed from the other genotypes in that they had lower root yield at H4 than at H3. H1 beet were consistently lower in CJP across all genotypes. Estimates of the means for Ovana at the bottom of Table 2 are based only on 2-3 replications and are listed here for a cursory comparison with the high sugar genotypes performance.

Anatomy, density and displacement measurements:

Mean anatomy measurements for genotypes summed over harvests, harvests summed over genotypes and the interactions of genotypes with harvests are given in Table 3. The root length of F1010, C51, and C40 was similar and significantly longer than the L19/2 or 576 roots. Root length increased with each succeeding harvest from H1 to H3, but not for H4. Genotypes C40 and F1010 had the greatest root diameter. Root diameter increased each harvest until H3 then

decreased for H4. Root diameter was consistently higher at H3 than for any of the other harvests. Genotypes C51 and 576 had a significantly smaller number of rings than L19/2, C40, or F1010. The number of rings that were developed was greater for H3 and H4 than for H1 and H2. Genotype 576 had the least number of developed rings at H2 and C40 had the largest number of rings at H3. Otherwise there was little variation of genotype x harvest for ring number. Considerable variation was noted for ring width of the five most developed rings in the root for genotype x harvest. When the ring widths were averaged C40 and F1010 had the greatest ring width at most harvests, 576 had the smallest, followed respectively by L19/2, then C51. Ovana had lowest number of vascular rings and the first three ring were considerably wider than all other genotypes.

The volume of water displacement and the percent salt that roots floated in are shown in Table 4. Summed over harvests, F1010 and C40 had the greatest volume and L19/2 and 576 had the smallest volume. Significant increases in volume were made at each harvest from H1 to H3, then decreased slightly for H4. C51 was unique among the genotypes in that it also showed a significant increase in volume from H3 to H4. C51 and C40 required significantly higher salt concentration to float the beets than L19/2, F1010, or 576. Genotype 576 required the lowest concentration of salt to float the beets. Significantly higher concentrations of salt were required for each harvest from H1 to H4 to float the roots. Linear regression analysis was utilized to determine if there was a correlation between beet weight, beet volume displacement, percent salt in which beets floated, root length, root diameter, numbers of vascular rings, width of vascular rings, or root width with polarimeter percent. Only the percent salt in which beets floated showed good correlation with percent sucrose (R^2 = 0.89).

Osmometer Analysis:

The most concentrated solution in beet fresh tissue was only slightly but consistently higher than that of the crushed tissue sample for all genotypes (Table 5). This would be expected for cells containing sugar solution in a large vesicle. Molal concentration of fresh tissue ranged from 0.55 to 1.05; molal concentration of crushed tissue ranged from 0.5 to 1.0. The average difference from fresh to crushed sample was 0.05 molal. These solute concentrations correspond to 0.95 to 1.82 L water/mole for the fresh tissue and 1 to 2 for the crushed tissue. Accounting for

3/4 of the composition being carbohydrates, this corresponds to a range of 2.2 to 4.4 g water/g dry tissue [1L water/mole of sucrose = 2.9 g water/g sucrose]. These values of 2.2 to 4.4 are slightly lower than the water data (g water/ g dry tissue) of 3 to 7 which is typical of the higher estimate of sugar concentration in crushed tissue than in expressed juice. Wetter beets have a higher percent of water outside the cell than dryer beets, 10 vs 5%, respectively.

There was a continuity of data from the fodder beet to the highest sugar line when plotting the osmometer data for the four harvests (Figure 1). There was a high correlation between sugar concentration on a fresh juice basis as determined by HPLC and/or polarimetry and molal concentration determined by osmometry. Linear regression analysis of percent sucrose vs molal concentration had a R^2 =0.911. Linear regression analysis of mg TL CHO/g juice (HPLC) vs molal concentration had a R^2 =0.896.

There were significant differences between the molal concentration of the sugarbeet juice between varieties and over the growing season (Table 5). Varieties F1010 and 576 had significantly lower solute concentrations than the other genotypes. This was the same result as found for the polarimeter determined sucrose percentage over all harvests (Table 2). This indicates that for these varieties, osmometer analysis of the juice is a good predictor of sugar concentration. An advantage of osmometer analysis is that it is quick, reliable, requires no chemicals and yields results within minutes after extracting tissue from the beet. The six genotypes in this study showed a correlation R^2 = 0.91. for osmometry results correlated to polarimeter percent sucrose.

Dry Weight Analysis:
About 1/4 of the dry weight composition of all cultivars was water insoluble structural material (Table 6). There was a significant difference in water content of the beet root among genotypes (L19/2, C51, and C40 had no significant difference but F1010 and 576 were significantly different from all other genotypes) (Table 6). Beet root water content ranged from 3 to 7 g water/g dry tissue.

HPLC Analysis:
When data were expressed as per g of juice, there was a significant difference between genotypes in the amount of sucrose

(Table 7). L19/2, C51 and C1 were similar and exceeded F1010. All four of these genotypes exceeded the 576 genotype. These data correlate perfectly with sucrose percentage as determined by the traditional polarimeter method (Table 2). However, when data are summarized as per g of dry tissue, there was no significant difference between genotypes in the amount of sucrose or total carbohydrate (which would be mostly sucrose; Table 7). The genotypes had accumulated the same amount of sucrose on a dry weight basis. This may have been true even for Ovana but the lack of replication, due to decimation by deer feeding, left too few replications to determine that. These data suggest that the previously reported differences in sucrose accumulation for high sucrose genotypes represents differences in water accumulation since sucrose content on a dry weight basis does not change but water accumulation does.

About 3/4 of the dry weight composition was water soluble carbohydrate, and, the majority of the total water soluble carbohydrate is sucrose. Glucose and fructose content did vary between genotypes but in no discernable "high" to "low" pattern. These sugars represented only about 0.45% of the total water soluble carbohydrates.

While the HPLC method is straight forward, it is very time consuming and requires expensive instruments. The advantage is that it is an extremely reliable method and is a good check against the standard polarimeter values of percent sugar. If one or more genotypes of beets had a disproportionate amount of glucose or fructose, the polarimeter values for percent sugar would be way off (polarimetry does not measure just sucrose but also glucose and fructose; fructose has a negative influence on the reading while glucose and sucrose concentration have similar influences on the reading). The HPLC isolates sucrose for quantitation and thus is the more accurate method when other sugars are present especially when other sugars are present in differing proportions.

DISCUSSION

The plant stand in this experiment was not good and unfortunately may have biased some of the results. There was a problem with our drill in that the press wheels of the "A" seeding unit were off to the right 3 inches instead of being centered in the row. This resulted in less seed emergence and poorer plant stands in plots seeded with this drill unit. Also, we had a problem

with deer grazing in this experiment. The Ovana entry was completely devastated in plots scheduled for harvest 2, and only 1-2 replicates were available for sampling in harvest 3 and 4. Since this was a pilot experiment, where we hoped to develop methods to more fully understand the genetic and physiological factors controlling seasonal sucrose accumulation, we continued the experiment to glean information that might be useful in future more critical experimentation. L19/2 was significantly lower in root yield and particularly in sucrose percentage than expected. In 1990 and 1991 field experiments (1990 Report p. E12 and 1991 Report p. E25) L19/2 had higher sucrose percentage than either C51 or C40. The HPLC data suggests that future research should be directed toward determining the basic factors governing water accumulation in the cells of high sugar genotypes that show significant differences in sucrose percentage on a fresh weight basis.

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Table 1. Sugar yield, root yield, sucrose percentage, and clear juice purity percentage for diverse sugarbeet genotypes grown at the B&B farm and harvested in October of 1994; n=6.

Genotype	RWSA #	RWST #	Tons/ acre	Suc %	CJP %
1 L19/2	5432 *B	319.2 A	16.81 C	21.76 AB	94.05 A
2 C51	6806 A	312.7 A	21.81 AB	22.05 A	92.66 A
3 C40	7748 A	318.1 A	24.40 A	21.78 AB	93.87 A
4 F1010	7479 A	308.2 A	24.34 A	20.91 B	94.37 A
5 576	5412 B	285.1 B	18.81 BC	19.32 C	94.66 A
Mean	6575	308.6	21.23	21.17	93.92
lsd (0.05)	1148	22.1	3.45	0.95	2.13

*Duncan's Multiple Range Test - Means with same letter suffix are not significantly different at the 0.05 level

Table 2. Sugar yield, root yield, sucrose percentage, and clear juice purity percentage for diverse sugarbeet genotypes grown at the B&B farm and harvested in July, August, September, and October of 1994.

Gentotype	Harv.	RWSA #		RWST #		Tons/ acre		Suc %		CJP %	
1 L19/2		3856	B*	254.4	A	13.62	C	18.17	A	91.95	C
2 C51		4174	AB	255.4	A	14.72	BC	18.24	A	92.22	BC
3 C40		4578	A	253.6	A	16.37	AB	17.97	A	92.56	A-C
4 F1010		4487	A	242.8	B	16.97	A	17.12	B	92.96	AB
5 576		3297	C	217.8	C	13.69	C	15.44	C	93.05	A
	1	695	D	155.9	D	4.45	C	12.59	D	88.88	B
	2	3158	C	236.7	C	13.32	B	16.64	C	93.50	A
	3	5885	B	277.8	B	21.37	A	19.16	B	93.89	A
	4	6575	A	308.6	A	21.17	A	21.17	A	93.92	A
1 L19/2	1	681	G	146.5	I	4.62	G	12.53	JK	86.92	D
	2	3228	EF	249.2	DE	12.92	EF	17.66	FG	92.90	B
	3	6083	B-D	302.6	A-C	20.13	A-C	20.73	CD	93.94	AB
	4	5432	CD	319.2	A	16.81	C-E	21.76	AB	94.05	AB
2 C51	1	753	G	158.4	HI	4.80	G	12.76	J	88.88	C
	2	3377	E	250.6	DE	13.48	EF	17.48	G	93.66	AB
	3	5758	B-D	299.8	BC	19.13	BC	20.66	CD	93.69	AB
	4	6806	AB	312.7	AB	21.48	AB	22.05	A	92.66	B
3 C40	1	753	G	162.0	HI	4.70	G	12.97	J	89.12	C
	2	3622	E	244.5	EF	14.92	D-F	17.20	G	93.34	AB
	·3	6188	B-D	289.8	C	21.47	AB	19.93	DE	93.90	AB
	4	7748	A	318.1	AB	24.41	A	21.78	AB	93.87	AB
4 F1010	1	817	G	165.9	H	4.96	G	12.97	J	89.98	C
	2	3326	E	230.4	F	14.49	EF	16.21	H	93.53	AB
	3	6325	BC	266.7	D	24.08	A	18.41	F	93.95	AB
	4	7479	A	308.2	AB	24.34	A	20.91	BC	94.37	AB
5 576	1	470	G	146.7	I	3.14	G	11.74	K	89.49	C
	2	2236	F	209.0	G	10.77	F	14.65	I	94.08	AB
	3	5071	D	230.3	F	22.04	AB	16.06	H	93.96	AB
	4	5413	CD	285.1	C	18.81	B-D	19.32	E	94.66	A
6 Ovana	1	415		87.5		4.79		8.42		84.89	
	2										
	3	3677		138.5		26.55		11.35		88.78	
	4	2874		132.0		19.84		11.87		85.65	

*Duncan's Multiple Range Test - Means with same letter suffix are not significantly different at the 0.05 level

Table 3. Morphological results for diverse sugarbeet genotypes grown at the B&B farm and harvested in July, August, September, and October of 1994.

Variety	Harvest	Root Length --mm--	Root Diameter --mm--	No. Rings	Average ring width --mm--
1 L19/2		218 *B	87 B	7.8 AB	6.7 B
2 C51		242 A	87 B	7.2 CD	7.0 B
3 C40		240 A	95 A	8.2 A	7.5 A
4 F1010		247 A	93 A	7.5 BC	7.6 A
5 576		225 B	79 C	7.0 D	6.7 B
	1	206 C	62 D	6.5 C	5.0 C
	2	223 B	92 C	6.0 D	8.2 A
	3	253 A	103 A	9.0 A	7.7 B
	4	254 A	98 B	8.6 B	7.6 B
1 L19/2	1	189 J	63 H	7.0 EF	4.8 HI
	2	217 E-J	91 EF	6.3 F-H	8.1 A-E
	3	233 B-H	98 C-F	9.3 B	6.8 G
	4	232 B-H	95 D-F	8.4 CD	7.4 E-G
2 C51	1	212 G-J	61 H	6.2 F-H	5.0 HI
	2	226 C-I	93 D-F	5.8 GH	8.1 A-E
	3	258 A-D	101 B-D	8.8 B-D	7.4 D-G
	4	273 A	95 D-F	8.1 D	7.6 C-G
3 C40	1	213 F-J	67 H	7.2 E	5.3 H
	2	226 C-I	96 D-F	6.1 GH	8.3 A-C
	3	265 AB	113 A	10.3 A	8.3 A-D
	4	255 A-D	107 A-C	9.3 BC	8.0 A-F
4 F1010	1	224 D-J	66 H	6.5 E-G	5.4 H
	2	243 A-G	99 B-F	6.3 E-G	8.8 A
	3	259 A-D	108 AB	8.6 B-D	8.6 AB
	4	262 A-C	100 B-E	8.7 B-D	7.8 B-F
5 576	1	194 IJ	51 I	5.7 GH	4.4 I
	2	206 H-J	80 G	5.4 H	7.9 B-F
	3	250 A-E	94 D-F	8.2 D	7.4 E-G
	4	248 A-F	90 F	8.6 B-D	7.2 FG
6 Ovana	1	175	62	3.9	5.3
	2				
	3	267	92	5.0	8.7
	4	234	92	4.8	8.7

*Duncan's Multiple Range Test - Means with same letter suffix are not significantly different at the 0.05 level

Table 4. Sugar beet water volume displaced and the percent of salt water that the sugar beets floated in for diverse sugarbeet genotypes grown at the B&B farm and harvested in July, August, September, and October of 1994.

Variety	Harvest	Water Volume Displaced	% Salt Beets Floated	n
1 L19/2		576*C	9.0 B	48
2 C51		627 BC	9.7 A	48
3 C40		689 AB	9.8 A	48
4 F1010		752 A	8.9 B	48
5 576		572 C	7.9 C	48
	1	217 D	6.3 D	60
	2	610 C	8.8 C	60
	3	943 A	9.7 B	60
	4	803 B	11.4 A	60
1 L19/2	1	231 I	6.3 I	12
	2	585 GH	8.6 FG	12
	3	836 C-E	10.0 DE	12
	4	652 E-G	11.0 BC	12
2 C51	1	250 I	6.3 I	12
	2	608 FG	9.3 EF	12
	3	781 C-F	10.8 B-D	12
	4	868 B-D	12.4 A	12
3 C40	1	226 I	6.6 I	12
	2	696 D-G	9.4 E	12
	3	1027 AB	10.7 CD	12
	4	809 C-E	12.4 A	12
4 F1010	1	237 I	6.5 I	12
	2	692 D-G	8.5 G	12
	3	1123 A	9.3 EF	12
	4	958 A-C	11.5 B	12
5 576	1	143 I	6.1 I	12
	2	469 H	8.0 GH	12
	3	948 A-C	7.7 H	12
	4	728 D-G	9.8 E	12
6 Ovana	1	237	4.5	10
	2			0
	3	1285	4.0	2
	4	1047	5.7	6

*Duncan's Multiple Range Test - Means with same letter suffix are not significantly different at the 0.05 level

Table 5. Osmometer results of brei juice and sugarbeet tissue (fresh and crushed) for diverse sugarbeet genotypes grown at the B&B farm and harvested in July, August, September, and October of 1994.

Variety	Harv.	Juice	Tissue Fresh	Crushed	Ratio Fresh/Crushed	n
		--		molality	--	
1 L19/2		0.827*A	1.009 AB	0.955 AB	1.06 AB	24
2 C51		0.828 A	1.057 A	1.028 A	1.04 B	24
3 C40		0.809 A	0.971 B	0.921 B	1.06 AB	24
4 F1010		0.751 B	0.903 C	0.827 C	1.10 A	24
5 576		0.644 C	0.809 D	0.744 D	1.10 A	24
	1	0.554 D	0.661 C	0.609 C	1.09 A	30
	2	0.697 C	0.873 B	0.816 B	1.08 AB	30
	3	0.861 B	1.111 A	1.048 A	1.07 AB	30
	4	0.977 A	1.153 A	1.107 A	1.05 B	30
1 L19/2	1	0.570 I	0.707 E	0.669 FG	1.06 A-D	6
	2	0.732 FG	0.953 D	0.899 E	1.06 A-D	6
	3	0.981 BC	1.174 BC	1.105 C	1.08 A-D	6
	4	1.027 AB	1.202 BC	1.149 BC	1.05 B-D	6
2 C51	1	0.565 I	0.671 E	0.629 G	1.07 A-D	6
	2	0.748 F	0.945 D	0.894 E	1.06 A-D	6
	3	0.957 CD	1.349 A	1.341 A	1.01 D	6
	4	1.043 A	1.264 AB	1.247 AB	1.02 CD	6
3 C40	1	0.568 I	0.662 E	0.617 G	1.09 A-D	6
	2	0.735 FJ	0.874 D	0.815 E	1.07 A-D	6
	3	0.908 D	1.137 C	1.097 C	1.04 CD	6
	4	1.027 AB	1.213 BC	1.156 BC	1.05 B-D	6
4 F1010	1	0.561 I	0.652 E	0.593 G	1.10 A-C	6
	2	0.681 GH	0.863 D	0.798 EF	1.09 A-D	6
	3	0.805 E	0.988 D	0.867 E	1.14 AB	6
	4	0.957 CD	1.107 C	1.050 CD	1.05 B-D	6
5 576	1	0.505 J	0.614 E	0.536 G	1.15 A	6
	2	0.588 I	0.732 E	0.674 FG	1.09 A-D	6
	3	0.653 H	0.909 D	0.833 E	1.09 A-D	6
	4	0.832 E	0.981 D	0.932 DE	1.06 A-D	6
Ovana	1	0.415	0.448	0.421	1.07	6
						(4 juice)
	2		0.514	0.462	1.11	3
	3	0.507	0.623	0.598	1.05	2
						(1 juice)
	4		0.658	0.559	1.19	3

*Duncan's Multiple Range Test - Means with same letter suffix are not significantly different at the 0.05 level

Table 6. Water insoluble dry matter and water content of diverse sugarbeet genotypes grown at the B&B farm and harvested in July, August, September, and October of 1994.

Variety	Harv.	Water insoluble	Water	n
		-- g/g dry tissue --		
1 L19/2		0.223 ab	3.327 c	24
2 C51		0.215 b	3.371 c	24
3 C40		0.228 ab	3.380 c	24
4 F1010		0.239 a	3.585 b	24
5 576		0.235 a	4.027 a	24
	1	0.232 a	4.683 a	30
	2	0.224 a	3.632 b	30
	3	0.219 a	3.110 c	30
	4	0.239 a	2.728 d	30
1 L19/2	1	0.228 ab	4.697 b	6
	2	0.203 ab	3.258 ef	6
	3	0.230 ab	2.742 hi	6
	4	0.245 ab	2.612 i	6
2 C51	1	0.225 ab	4.630 b	6
	2	0.198 b	3.407 e	6
	3	0.203 ab	2.848 g-i	6
	4	0.232 ab	2.600 i	6
3 C40	1	0.225 ab	4.493 b	6
	2	0.240 ab	3.502 e	6
	3	0.220 ab	2.928 gh	6
	4	0.225 ab	2.597 i	6
4 F1010	1	0.247 ab	4.555 b	6
	2	0.237 ab	3.768 d	6
	3	0.233 ab	3.235 ef	6
	4	0.240 ab	2.783 g-i	6
5 576	1	0.237 ab	5.040 a	6
	2	0.242 ab	4.223 c	6
	3	0.207 ab	3.798 d	6
	4	0.253 a	3.047 fg	6
Ovana	1	0.272	6.852	5
	2			0
	3	0.208	5.637	1
	4			0

Table 7. High pressure liquid chromatography results of brei juice analysis on diverse sugarbeet genotypes grown at the B&B farm and harvested in July, August, September, and October of 1994.

Variety	Harv.	S	TL CHO	S	TL CHO	n
		-mg CHO/g dry tissue-		-mg CHO/g juice-		
1 L19S		719.7a	722.9a	182.9a	183.7a	24
2 C51		734.4a	737.0a	183.5a	184.2a	24
3 C40		736.9a	739.9a	183.5a	184.2a	24
4 F1010		730.7a	734.1a	172.6b	173.4b	24
5 576		732.1a	735.4a	156.7c	157.4c	24
	1	687.2c	691.4c	126.7d	127.5d	30
	2	755.2a	757.7a	172.3c	172.9c	30
	3	747.8ab	750.8ab	193.9b	194.7b	30
	4	732.8b	735.5b	210.5a	211.3a	30
1 L19S	1	687.8b-d	692.3bc	126.2f	127.0g	6
	2	733.3a-d	735.7a-c	181.0c	181.6cd	6
	3	727.7a-d	730.7a-c	207.3a	208.0a	6
	4	730.0a-d	732.9a-c	217.2a	218.0a	6
2 C51	1	688.8b-d	692.6bc	127.9f	128.6g	6
	2	750.6a	752.6a	178.6cd	179.1de	6
	3	765.1a	767.6a	210.2a	210.9a	6
	4	733.0a-d	735.3a-c	217.5a	218.1a	6
3 C40	1	685.0cd	688.8c	130.6f	131.3g	6
	2	766.9a	769.4a	180.3c	180.9cd	6
	3	757.5a	760.3a	204.4ab	205.2ab	6
	4	738.3a-c	741.1a-c	218.8a	219.6a	6
4 F1010	1	691.9b-d	696.2bc	130.6f	131.5g	6
	2	752.3a	755.8a	166.2de	166.9ef	6
	3	747.6a	750.8a	187.5c	188.3cd	6
	4	730.8a-d	733.6a-c	206.2ab	207.0ab	6
5 576	1	682.7d	686.9c	118.4f	119.1g	6
	2	773.0a	775.3a	155.3e	155.8f	6
	3	741.0ab	744.7ab	160.1e	160.9f	6
	4	731.8a-d	734.8a-c	192.9bc	193.8bc	6
6 Ovana	1	595.6	600.3	79.3	79.9	5
	2					0
	3	762.3	770.4	118.6	119.8	1
	4					0

S=sucrose; TL CHO=total water soluble carbohydrates.
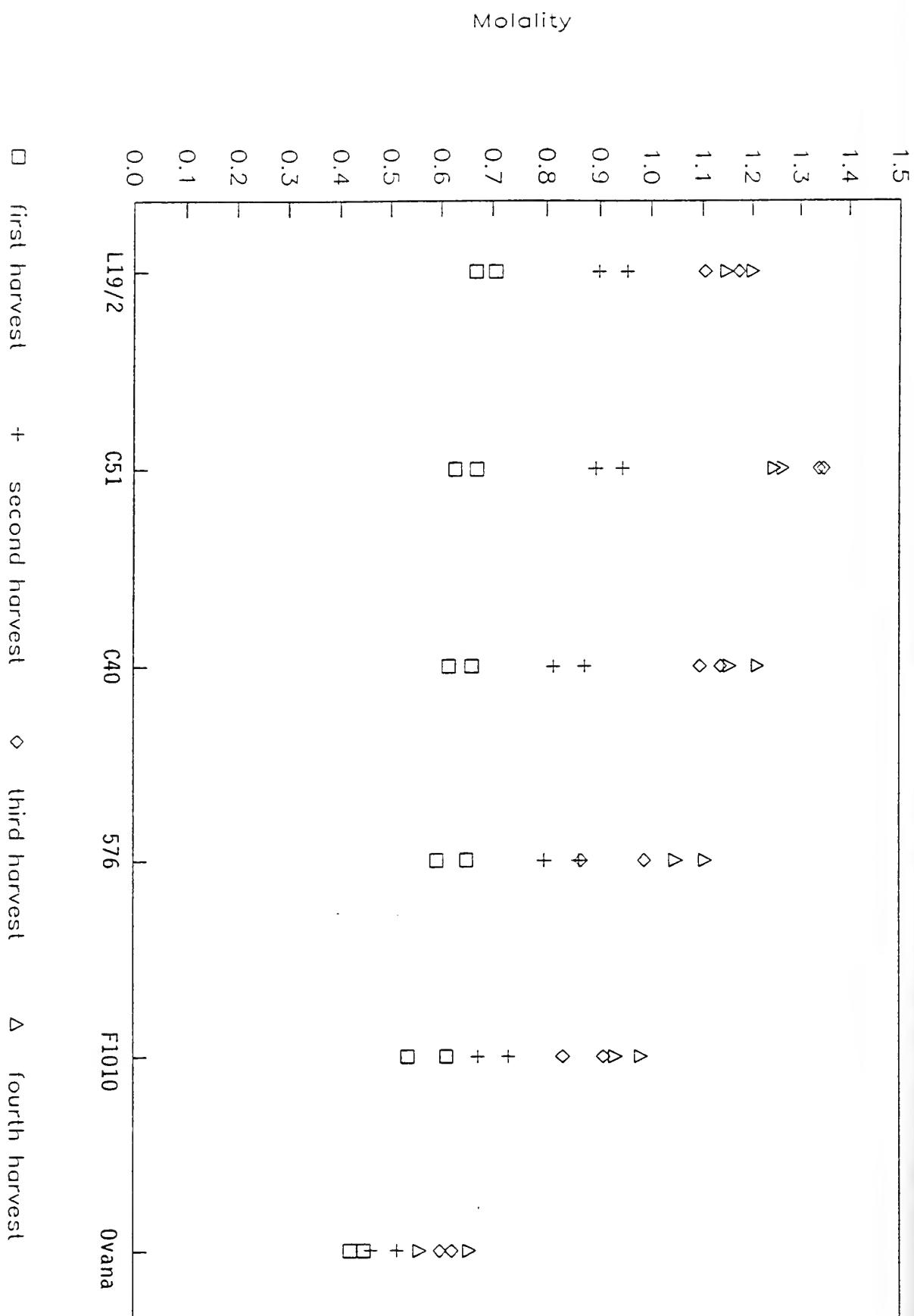
Figure 1. <u>Osmometry data</u>. Sugar beets grown at the B&B farm and harvested in July, August, September, and October of 1994. The concentration in the fresh tissue was higher than in the crushed tissue for each harvest and genotype.

□ first harvest   + second harvest   ◇ third harvest   △ fourth harvest

SUGARBEET RESEARCH

1994 Report

Section F

University of Idaho
Idaho

Dr. S. L. Hafez

CONTENTS

SUGARBEET CYST NEMATODE MANAGEMENT

Saad L. Hafez

INTRODUCTION

The sugarbeet cyst nematode, *Heterodera schachtii* Schmidt, is an economically damaging pest in Idaho and Eastern Oregon and many sugarbeet growing regions of the world. Management is complicated by the longevity of cysts and eggs, a wide range of weed hosts, and the lack of economical and effective nematicides. Sugarbeet cyst nematode management involves disruption of hatching, host finding, penetration, development, and reproduction.

A promising approach is the use of catch crops, plants that may stimulate egg hatch, penetration but are poor hosts for the nematode (to complete the life cycle). Various plants with potential as trap crops have been shown to stimulate egg hatch, including sugarbeet (*Beta vulgaris*), oilseed radish (*Raphanus sativus* var. *oleifera*), white mustard (*Sinapis alba*), and buckwheat (*Fagopyrum esculentum*). Nematode-resistant cruciferous crops, particularly oilseed radish, may be useful as crop rotations that reduce *H. schachtii* populations. Cultivars of oilseed radish, white mustard, and buckwheat that stimulate hatch and depress *H. schachtii* reproduction have been developed in Europe. The research presented here was conducted to assess the usefulness of these cultivars for *H. schachtii* management in sugarbeet production in Idaho and Eastern Oregon.

I.   The effect of different oil radish and mustard varieties fall planted on sugarbeet root yields planted in the following season in heavily infested field.

Seven varieties of oil radish (*Raphanus sativus* var. *oleifera*) and white mustard (*Sinapis alba*) were planted following wheat in sugarbeet cyst nematode infested field in the fall of 1993 in Parma, Idaho. Each variety was replicated five times in a complete randomized block design and a fallow treatment was included as a control check for comparison. All varieties were mechanically chopped three months after planting. Roots and forages were incorporated in the soil by double discing. Oil radish (*Adagio* var.) causes the highest % of reduction in comparison to fallow. White mustard (*Martigena* var.) causes the lowest % of reduction. Sugarbeet variety HM-WS-90 was planted following the oil radish and white mustard to evaluate their effect on sugarbeet yield. No nematicides were added to this field and standard insecticides for maggot control were applied at planting.

Results showed that Adagio, Ultima and Maxi increased sugarbeet root yield significantly in comparison with the fallow (no plant) treatment. There were no significant difference in root yield in the other varieties included in this test (Table 1).

II.   Green manure crops different planting date.

A.   Planting oil radish seed in wheat field before the last irrigation.

Oil radish seeds were planted by hand in wheat field before the last irrigation. Radish seed germinated but it did not survive until wheat harvest.

B.   Early and late Fall planting dates following grain harvest.

Two planting dates (Early, Aug 9, 1994 and late, Aug 25, 1994) of oil radish and mustard were established to determine how late these crops can be planted in southwestern Idaho to be effective in controlling the sugarbeet cyst nematode. Soil samples before planting in the fall and in the following spring were collected for nematode assay. Plant samples were collected from each planting date for measuring plant biomass. Both planting dates reduced nematode population significantly and the early planting date produced a higher amount of biomass than the late planting date.

III.   <u>Effect of Telone II, Vapam and Rapeseed oil meal on sugarbeet root yield, Parma, 1994</u>.

Telone II, Vapam and Rapeseed oil meal were hand applied in the fall of 1993 at the rate of 20 G, 50 G and 2 T/A. Telone II was injected by a hand gun at a depth of 12" and 12" apart in the bed in a zig zag pattern. Vapam was mixed with water (1:1) and applied the same as Telone II. Rapeseed oil meal was hand applied in a broadcast pattern and incorporated by rototiller. Each treatment was replicated five times in a complete randomized block design and untreated control was included. Soil samples before and after treatment were collected for nematode assay. Sugarbeet variety HM-WS-90 was planted in the following spring to evaluate the effect of these treatments on sugarbeet yield. Results showed that all treatment increased the root yield significantly in comparison with the untreated check. Telone II treatment produced the highest yield (Table 2).

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Hafez, S. L. 1994. Cultural practices for growing oil radish or white mustard in sugarbeet rotation for nematode management. Parma Ag Notes. Vo. 1(2).

Hafez, S. L. and D. Bowers. 1994. Managing the green manure crops for sugarbeet nematode management. Proceeding of the University of Idaho Winter School. 26:263-264.

Table 1. Effect of fall planted oil radish and mustard varieties on sugarbeet yield planted in the following spring. Parma, 1994.

Oil Radish or mustard var.	Sugarbeet** Root yield T/A	Yield increaese T/A	% of sugar
Adagio R.	37.2 a*	8.8	15.8 a
Pegletta R.	29.7 d	1.3	15.8 a
Ultimo R.	33.4 b c	5.0	15.8 a
Remonta R.	29.7 d	1.3	16.0 a
Maxi M.	36.8 b c	8.4	15.8 a
Metex M.	30.0 c d	1.6	15.9 a
Mortigena M.	28.4 d	0.0	16.0 a
No plant	28.4 d	--	15.8 a

*Means followed by the same letter are not significantly different.
**Values are means of five replicates.

Table 2. Effect of Telone II, Vapam and Rapesed oil meal on sugarbeet yield. Parma, 1994.

Treatments	Rate/A	Root yield** T/A	Yield increase T/A	% of sugar
Telone II	20 g	43.1 a*	14.7	15.6 a b
Vapam	50 g	35.7 b c	7.3	15.5 a b
Rapeseed Meal	2 T	33.0 b c	4.6	14.7 b
Untreated	--	28.4 d	0	15.8 a

*Means followed by the same letter are not significantly different.
**Values are means of five replicates.
Telone II was hand injected at 12" depth, 12" apart in a zig zag pattern.
Vapam was mixed with water (1:1) and applied the same as Telone II.

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SUGARBEET RESEARCH

1994 Report

Section G

Texas Agricultural Experiment Station
Bushland, Texas

Dr. C. M. Rush
Dr. G. J. Michels

Cooperation:

Imperial Holly - Hereford, Texas

CONTENTS

ETIOLOGY AND EPIDEMIOLOGY OF THE RHIZOMANIA DISEASE COMPLEX (BSDF Project 503)

HARVESON, R. M., and C. M. RUSH. 1994. Movement of BNYVV-infested *Polymyxa betae* **from an inoculated point source.** 1994 Ann. Mtg. Amer. Phytopath. Soc., Albuquerque, NM, August 6-10, 1994.

A 3-yr study was initiated in 1992 to determine how BNYVV spreads from a known point source of inoculum as influenced by irrigation and tillage. Each year the test consisted of four 9 x 30 m plots, each containing twelve 76-cm beds. The first 3 m of each of the two outside rows of each plot were planted with HH39 sugar beet seed coated with powdered sugar beet roots infested with viruliferous *P. betae* cystosori. These areas constituted the point sources. The remainder of the test was planted with untreated seed and plots were irrigated May 14 and 17 for 1992 and 1993 studies, respectively. Half the study was watered every two weeks and the other half every four weeks. During the season, plant samples were collected at various intervals, away from the point source, and assayed by ELISA for BNYVV incidence. At the end of each season, soil samples were also collected and assayed. Plots were then mechanically harvested. After bed preparation for the 1993 season, soil samples were collected to determine virus movement by soil tillage. The plant samples showed virtually no virus movement outside inoculated areas. After the 1992 season, only five soil samples (2%) were positive. Soil samples collected for tillage effect before the 1993 season contained 29 positive samples (12%). In 1993, no plant samples proved to be infected due to irrigation.

HARVESON, R. M., and C. M. RUSH. 1995. Studies of vegetative compatibility among isolates of *Fusarium oxysporum* **f. sp.** *betae* **causing different disease symptoms.** 28th Bien. Mtg. Amer. Soc. Sugar Beet Technol., New Orleans, LA, March 8-11, 1995.

Over a three-year period (1992-1994), 160 *Fusarium oxysporum* f. sp. *betae* isolates were collected from sugar beet and pigweed plants from seven counties in Texas. All isolations were made from surface-sterilized root pieces grown on half-strength potato dextrose agar. They were separated into two groups -- those causing tip rot and those causing only vascular necrosis. They were then stored on either sterile filter paper or soil. 132 of the 160 isolates were actually used for vegetative compatibility evaluations. 28 isolates were chosen as testers. They were paired in all possible combinations to determine the number of vegetative compatibility groups (VCGs) present. Those that produced dense, aerial mycelia at point of colony intersection were considered vegetatively compatible. Those that are vegetatively compatible are considered to be genetically similar and are placed in the same VCG. Six VCGs have been identified from the 28 testers. Most of the isolates (19 of 28) fall into one group. The remaining 104 isolates are being screened against one member of each of the 6 established VCGs. To date, VCG 1 has 53 members, with VCGs 2-6 containing 2, 12, 2, 2, and 2 isolates, respectively. No relationship exists

between VCG and root rot symptom or host. Results indicate that endemic populations of *F. oxysporum* have been present in Texas for some time.

HEIDEL, G. B., and C. M. RUSH. 1995. Effects on growth of two sugar beet cultivars infected by BNYVV, BSBMV, or BNYVV + BSBMV. 28th Bien. Mtg. Amer. Soc. Sugar Beet Technol., New Orleans, LA, March 8-11, 1995.

Beet soilborne mosaic virus (BSBMV), a rod-shaped virus transmitted by *Polymyxa betae*, closely resembles beet necrotic yellow vein virus (BNYVV), but the viruses are serologically distinct. Two studies were conducted to evaluate the effect of BSBMV on sugar beet growth. For the first study, sugar beet seedlings (cv. HH67 and Rhizosen) were vortexed in inoculum of one of three BSBMV isolates (BSBMV-1, BSBMV-2, BSBMV-3), BNYVV, or BSBMV + BNYVV. Inoculum was prepared by grinding symptomatic *Chenopodium quinoa* leaf tissue in 0.1 M potassium phosphate buffer, pH 7.4, with 0.02 M sodium sulfite and 0.45% (w:v) carborundum. Top and root dry weights of infected sugar beets in all the treatments were reduced, but the reduction was not significant compared to both mock-inoculated (buffer + carborundum) and non-inoculated controls. In the second study, seeds of HH67 or Rhizosen were planted directly over lateral beet roots infested with viruliferous *P. betae*. Top and root dry weights of sugar beets in all virus treatments were significantly reduced in comparison to those of non-viruliferous *P. betae* and non-infested control beets. Studies suggest that BSBMV is virulent, but field observations do not always support these results. Use of the vortex method to inoculate sugar beets can avoid the presence of confounding pathogens maintained in *P. betae* cultures, but the use of viruliferous *P. betae* as inoculum may better reflect field disease development.

RUSH, C. M., and R. M. HARVESON. 1995. Reduction of sugar beet root diseases by cultivar selection and irrigation management. 28th Bien. Mtg. Amer. Soc. Sugar Beet Technol., New Orleans, LA, March 8-11, 1995.

A study was begun in 1994 to evaluate the efficacy of irrigation frequency and cultivar mixtures to control multiple soilborne pathogens. Four cultivars and four blend combinations were planted 13 April in a randomized complete block, split plot design with six replications. The main plots were irrigation levels and cultivars were the split treatment. Each plot consisted of four 100 ft rows. They were irrigated for emergence 15 April, followed by bi-monthly irrigations for the wet plots and one irrigation a month for the dry plots. Disease counts were made seven times during the season at 2-week intervals by destructively sampling infected plants from one row of each plot. All cultivars in the test were chosen because they are currently being used commercially in Texas. Ranger is a new cultivar that is a high sucrose producer, whereas MH9155 was bred for high root yields. Rhizosen is a rhizomania-resistant cultivar, and HH67 has good tolerance to *R. solani*. Entries that included MH9155 tended to produce the better results for most yield parameters. High

irrigation levels were correlated with high disease incidence and ratings. Few significant differences were seen from yield components between irrigation treatments. Results indicate that reduced irrigations could be beneficial for growers who are forced to plant into pathogen-infested soils.

RUSH, C. M., and G. B. HEIDEL. 1995. Variation in symptomatology and serotype among furoviruses infecting sugar beet. 28th Bien. Mtg. Amer. Soc. Sugar Beet Technol., New Orleans, LA, March 8-11, 1995.

Beet soilborne mosaic virus (BSBMV) is a multiparticulate rod-shaped virus transmitted by *Polymyxa betae*. It is similar to beet necrotic yellow vein virus (BNYVV), but the viruses are serologically different. BSBMV capsid molecular weight has been estimated at 22.5 kDa, and the genome is comprised of three to four RNA species. Sugar beets exhibiting typical BSBMV-like foliar symptoms were collected from fields in Colorado. Leaf samples were tested by ELISA. Two isolates (Neal, Amen) were positive for BSBMV. Three isolates (RC, LC, Schaeffer) repeatedly tested negative for BSBMV or had absorbance values that were higher than those of healthy controls but lower than those typically recorded for positive samples. A single 22-23 kDa protein species from each isolate was visualized in denaturing polyacrylamide gels. Using BSBMV-specific PCR primers, a single 700 bp product was amplified from RNA extracted from each isolate. Gel electrophoresis of RNA extracted from LC and RC virus preparations indicated the presence of four RNA species with a banding pattern similar to that of BSBMV. Virus isolates serologically different from BSBMV but similar in terms of symptom expression, capsid protein, RNA banding pattern and PCR products amplified using BSBMV-specific primers may comprise a serotype of BSBMV. Along with serological variation among BSBMV isolates, variation in foliar and root symptomatology has been observed.

VAUGHN, K. M., and C. M. RUSH. 1995. A survey of *Aphanomyces cochlioides* from sugar beet production areas in the United States and Canada. 28th Bien. Mtg. Amer. Soc. Sugar Beet Technol., New Orleans, LA, March 8-11, 1995.

Aphanomyces cochlioides is a soilborne fungus that causes black root, a serious sugar beet seedling disease. Tachigaren, a systemic fungicide that has activity against *Aphanomyces* spp. and other seedling pathogens, is widely used in Europe and Japan. Until the forthcoming registration of Tachigaren in the USA, the only control measures available to growers in the Texas Panhandle to reduce disease caused by *A. cochlioides* are to plant early when soils are cool and use limited irrigation to establish a stand. A survey was conducted to determine the geographical distribution of *Aphanomyces* and other major sugar beet seedling pathogens throughout production areas in the USA and Canada. In greenhouse experiments, soil samples from Canada, California, Colorado, Idaho, Michigan, Montana, Nebraska, Ohio, the Red River Valley, Texas, and Wyoming were screened for *Aphanomyces, Rhizoctonia,*

and *Pythium*. High levels of *Aphanomyces* were detected in soils from Montana, Ohio, and the Red River Valley, while *Rhizoctonia* was predominantly isolated in soils from Colorado, Idaho, and California. Also, high levels of *Pythium* were detected in California soils. Since Tachigaren is used in other countries to suppress *Aphanomyces*, a field study was conducted to evaluate the efficacy of Tachigaren as a seed treatment to control *Aphanomyces* on sugar beet seedlings in the Texas Panhandle. Tachigaren significantly reduced incidence of seedlings infected by *A. cochlioides*, but, in this study, it did not protect against infection by *Aphanomyces* the entire season.

Papers Published Since Abstracted in Previous Report

HARVESON, R. M., and C. M. RUSH. 1994. Evaluation of fumigation and rhizomania-tolerant cultivars for control of a root disease complex of sugar beets. Plant Dis. 78:1197-1202.

HEIDEL, G. B., and C. M. RUSH. 1994. Distribution of beet necrotic yellow vein virus, beet distortion mosaic virus, and an unnamed soilborne sugar beet virus in Texas and New Mexico. Plant Dis. 78:603-606.

RUSH, C. M., D. E. CARLING, R. M. HARVESON, and J. T. MATHIESON. 1994. Prevalence and pathogenicity of anastomosis groups of *Rhizoctonia solani* from wheat and sugar beet in Texas. Plant Dis. 78:349-352.

RUSH, C. M., R. FRENCH, and G. B. HEIDEL. 1994. Differentiation of two closely related furoviruses using the polymerase chain reaction. Phytopathology 84:1366-1369.

ETIOLOGY AND EPIDEMIOLOGY OF THE RHIZOMANIA DISEASE COMPLEX
BSDF Project 503

GROWTH OF TWO SUGAR BEET CULTIVARS INFECTED BY BNYVV, BSBMV, OR BNYVV + BSBMV

G. B. Heidel and C. M. Rush

In 1987, a complex of viruses infecting sugar beet in Texas was reported. One of the isolates was designated Texas 7 (TX7). Work published since that time referred to virus isolates from Texas that were serologically the same as the original TX7 isolate as beet soilborne mosaic virus (BSBMV). The name BSBMV will be used in this paper to refer to virus isolates that are serologically the same as the original TX7 isolate.

BSBMV is a multiparticulate, rod-shaped virus transmitted by *Polymyxa betae* Keskin. It is similar in morphology and mode of transmission to beet necrotic yellow vein virus, the causal agent of rhizomania.

BSBMV and BNYVV are, however, serologically distinct, and vary in the nature and frequency of observable root and foliar symptoms. Foliar symptoms associated with systemic infection by BNYVV in sugar beet include bright yellow vein banding, followed by veinal necrosis. Foliar BNYVV symptoms are observed rarely in field-grown sugar beets. Foliar symptoms caused by BSBMV in sugar beets include broader yellow vein banding and mottling. Unlike foliar BNYVV symptoms, foliar symptoms caused by BSBMV, though not widespread, can often be found without much difficulty in sugar beets grown in fields infested with the virus. These symptoms are usually observed later in the growing season.

Roots of sugar beets exhibiting BSBMV foliar symptoms can appear healthy. Field sugar beets have been collected, however, that exhibit symptoms similar to those caused by BNYVV. When tested by ELISA for both viruses, these beets often test positive for BSBMV and negative for BNYVV. It is not known if BSBMV is the causal agent of root symptoms resembling those caused by BNYVV.

Since BSBMV was first reported in Texas in 1987, it has been identified in several sugar beet-growing areas, including Colorado, Idaho and Nebraska. Given the widespread incidence of BSBMV and the lack of information on what effect, if any, it may have on sugar beets, two studies were initiated. The first objective of these studies was to determine the effect of BSBMV, both alone and in combination with BNYVV, on sugar beet growth. The second objective was to evaluate vortexing sugar beet seedlings in virus inoculum as a method of infecting sugar beets in the absence of *P. betae*.

Materials and Methods

In the first study, a variation of a vortex method used in studies involving BNYVV or beet soilborne virus, another *Polymyxa*-transmitted virus infecting sugar beet, was used. Three BSBMV isolates, one each from Colorado, Nebraska and Texas (BSBMV-1, BSBMV-2 and BSBMV-3, respectively), and BNYVV were inoculated to *Chenopodium quinoa* Willd. leaf tissue from sugar beet root tissue that tested positive for the respective virus. 0.2 g symptomatic *C. quinoa* was ground in 12 ml 0.1 M potassium phosphate buffer, pH 7.4, with 0.02 M sodium sulfite. Carborundum (600 mesh) was added at a rate of 0.45% (w:v). Twenty 14-day old sugar beet seedlings, HH67 or Rhizosen, were placed in inoculum contained in 50 ml centrifuge tubes and vortexed for 30 seconds using a Vortex-Genie™ on setting 7. After being left in the inoculum for 5 minutes, the seedlings were rinsed with deionized water and transplanted to one-gallon containers. Treatments included BSBMV-1, BSBMV-2, BSBMV-3, BSBMV + BNYVV, BNYVV, mock-inoculation with buffer and carborundum, and noninoculated transplanted seedlings. Treatments were replicated five times. Plants were maintained in the greenhouse and thinned from four to one plant per container six weeks after transplanting and harvested after three months.

In the second study, viruliferous *P. betae* was used as inoculum. BSBMV and BNYVV isolates were the same as those used in the vortex study. Nonviruliferous *P. betae* and a noninfested treatment were used as checks. Treatments were replicated 12 times. Sugar beet seed, HH67 or Rhizosen, was planted directly onto a small mass of lateral root tissue from sugar beets that tested positive for the respective virus. Root tissue was checked for the presence of *P. betae* cystosori. Plants were thinned to one per container approximately two months after planting and at harvest, four months after planting, fresh and dry root and top weights were determined. Root tissue and any symptomatic leaf tissue were tested by ELISA for both BSBMV and BNYVV.

Results and Discussion

Results of both studies mentioned here include only top and root dry weights of beets that both survived to harvest and tested as expected for the respective virus treatment.

Sample size in the vortex study was reduced by the number of beets that did not survive to harvest and the low percent infection detected by ELISA in sugar beets in all virus treatments. No treatment by variety interaction was detected, so data from both varieties were combined (Table 1). Among virus treatments, only top and root weights of sugar beets infected with BSBMV-3 were significantly lower than those of sugar beets in both the mock-inoculated and noninoculated control treatments. Top and root weights in other virus treatments were reduced compared only to those of beets in the noninoculated control treatment. Vortexing sugar beets in buffer alone reduced top and root dry weights compared to noninoculated controls, but the reduction was not significant. None of the beets in the BSBMV + BNYVV treatment both survived to harvest and tested positive for both viruses. Overall, the presence of virus was confirmed in 43% of sugar beets in virus treatments at harvest.

Table 1. Top and root dry weights of sugar beets surviving at harvest when mechanically inoculated by vortexing in virus inoculum. Root tissue of sugar beets tested as expected by ELISA for the respective treatments. Numbers followed by the same letter are not significantly different.

Treatment	Top (g)	Root (g)
BSBMV-1	14.6 bc	6.8 bc
BSBMV-2	15.0 bc	6.9 bc
BSBMV-3	11.8 c	3.8 c
BNYVV	16.0 bc	5.8 bc
BSBMV + BNYVV	.	.
Buffer	17.5 ab	12.3 ab
Noninoculated	21.6 a	18.3 a

Percent detectable virus infection in the second study, in which viruliferous *P. betae* was used as inoculum, was 65%. Most of the beets survived to harvest and tested positive for the respective virus treatment. As in the vortex study, no treatment by variety interaction was detected (Table 2).

Table 2. Top and root dry weights of sugar beets surviving at harvest when inoculated by viruliferous *Polymyxa betae*. Root tissue of sugar beets tested as expected by ELISA for the respective treatment. Numbers followed by the same letters are not significantly different.

Treatment	Top (g)	Root (g)
BSBMV-1	9.0 b	7.0 cd
BSBMV-2	8.5 b	7.8 cd
BSBMV-3	11.1 b	11.2 c
BNYVV	8.5 b	4.5 d
BSBMV + BNYVV	.	.
Polymyxa betae	14.3 a	18.7 b
Noninfested	16.2 a	25.3 a

Fewer than half of the sugar beets surviving at harvest in the BNYVV treatment tested positive for the virus, and none of the beets in the BSBMV + BNYVV treatment both

survived to harvest and tested positive for both viruses. About half the beets in this treatment did not survive to harvest. Top and root dry weights were significantly reduced in sugar beets infected by viruliferous *P. betae*, and root weight of beets in the nonviruliferous *P. betae* treatment was reduced compared to that of beets in the noninfested control treatment. Among virus treatments, root weight of sugar beets infected with BNYVV was only significantly less than that of beets infected with BSBMV-3, but it was somewhat lower than root weights of sugar beets infected with BSBMV-1 and BSBMV-2.

Several conclusions were drawn from these studies. As an experimental method, the use of viruliferous *P. betae* may be better than vortexing as a means of inoculating sugar beets to evaluate the effect of BSBMV on sugar beet growth. Detectable virus infection was 65% when viruliferous *P. betae* was used as inoculum, compared to 43% when sugar beets were mechanically inoculated by vortexing in virus inoculum. The presence of both virus and its natural vector in an experimental setting has the potential to more closely replicate disease development as it occurs in the field than does inoculation by virus alone.

However, there are advantages to inoculating sugar beets by the vortex method, which has the potential to provide a relatively quick method to evaluate pathogenicity among virus isolates or to screen sugar beet lines for tolerance to BSBMV. The presence of other soilborne sugar beet pathogens maintained in *P. betae* cultures can be avoided by mechanically inoculating sugar beets. The results of this study, in which viruliferous *P. betae* was used as inoculum, may well have been confounded by the presence of other soilborne pathogens. In future studies, seed planted will likely be treated and the plants will be drenched with fungicides to reduce the effects of other pathogens that might be present.

Finally, even though results of these studies suggest that BSBMV is virulent, field observations do not always support these results. As mentioned previously, roots of sugar beets exhibiting BSBMV-like foliar symptoms are often healthy-looking. But sugar beets exhibiting BNYVV-like root symptoms have been collected that test positive by ELISA for BSBMV only. Further work will be necessary to determine if these two extremes in observed symptomatology represent natural variation in the BSBMV population. Other contributing factors to the varying symptoms observed could include varietal response or environmental conditions.